

1 **A.25 VERNAL POOL TADPOLE SHRIMP**  
 2 **(*LEPIDURUS PACKARDI*)**



photo courtesy USFWS

3 **A.25.1 Legal and Other Status**

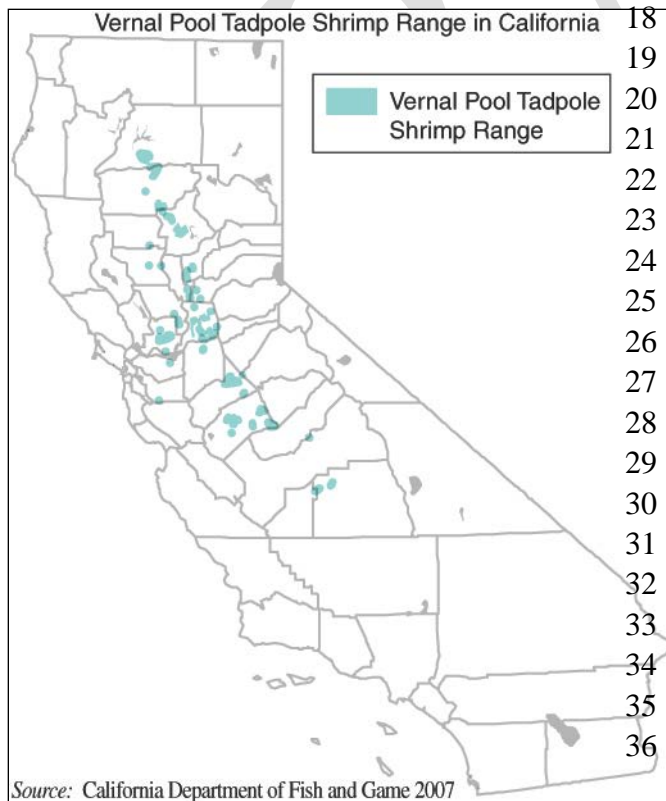
4 The vernal pool tadpole shrimp is listed as endangered under  
 5 the ESA throughout its range (USFWS 1994).

6 Critical habitat has been designated for vernal pool tadpole  
 7 shrimp, including sites in the Butte Regional HCP/NCCP  
 8 Plan Area. Critical habitat has been designated for vernal  
 9 pool tadpole shrimp, including areas in the Butte Regional HCP/NCCP Plan Area. Critical  
 10 habitat includes 59,015 acres (23,883 hectares) in Unit 3 (Vina Plains Unit), a portion of which is  
 11 in Butte County, and all of which is on private property. The Vina Plains Unit is located in the  
 12 northeast portion of the Sacramento Valley from Deer Creek in Tehama County to Chico in  
 13 Butte County (USFWS 2006).

14 **A.25.2 Species Distribution and Status**

15 **A.25.2.1 Range and Status**

16 The vernal pool tadpole shrimp is currently distributed across the Central Valley of California  
 17 and in the San Francisco Bay area. Populations are found in 18 vernal pool complexes in the



18 Sacramento Valley from east of Redding  
 19 in Shasta County south through the  
 20 Central Valley to the San Luis National  
 21 Wildlife Refuge in Merced County. It  
 22 also occurs in a single vernal pool  
 23 complex located on the San Francisco  
 24 Bay National Wildlife Refuge in the City  
 25 of Fremont, Alameda County. The  
 26 easternmost known location is around  
 27 1,065 meters (3,500 feet) in elevation in  
 28 the central Sierra Nevada foothills  
 29 (Merced County), with the westernmost  
 30 known locations in the San Francisco Bay  
 31 Area (Alameda County). The Bay Area  
 32 location is the only known population  
 33 outside of the Central Valley  
 34 (USFWS1994). The largest concentration  
 35 of vernal pool tadpole shrimp occurrences  
 36 is in the Southeastern Sacramento Vernal

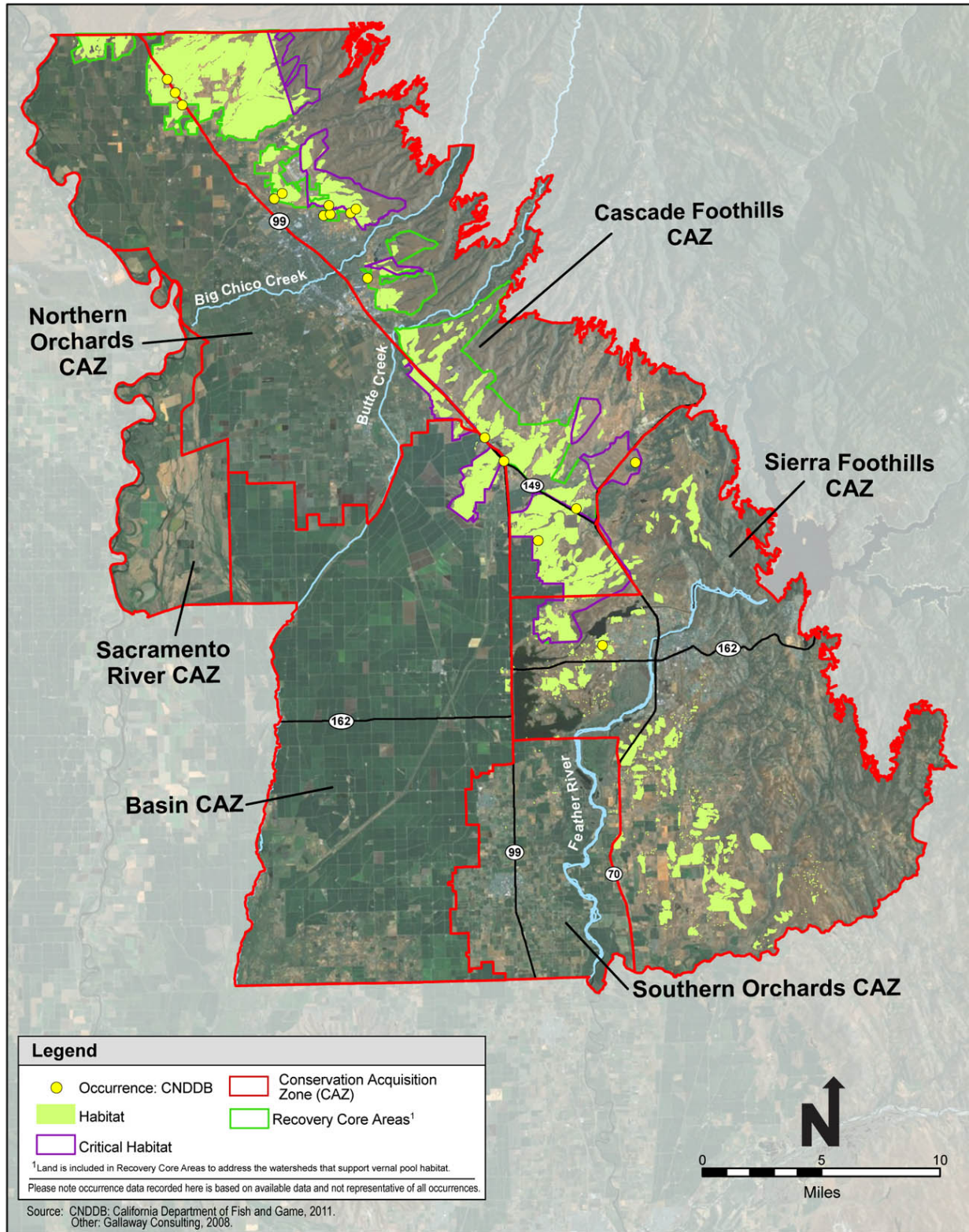
1 Pool Region, where the species occurs on a number of public and private lands in Sacramento  
2 County (USFWS 2005).

### 3 **A.25.2.2 Distribution and Status in the Plan Area**

4 In the Northeastern Sacramento Vernal Pool Region, vernal pool tadpole shrimp have been  
5 documented on private land in the vicinity of Chico in Butte County and in Tehama County at the  
6 Vina Plains Preserve, the Dales Lake Ecological Reserve, and on Caltrans land (USFWS 2005).  
7 There are 18 presumed extant records of observations for the vernal pool tadpole shrimp in Butte  
8 County, with some locations noting the species present in several pools. Along Highway 99 and  
9 Cana Highway, this species was reported from seven locations in 24 pools (with most reports from  
10 1993 and 1995). The species was also reported from three locations in the vicinity of Highway 149.  
11 In the vicinity of Chico, vernal pool tadpole shrimp are reported from five separate locations, most of  
12 them small complexes or isolated pools, with the exception of a mitigation site on private property  
13 where, in 1995, the species was reported to occur in 86 of the 196 mitigation pools. In 1998, vernal  
14 pool tadpole shrimp were reported from the Vina Plains Preserve in Butte and Tehama counties,  
15 although the number of individuals was not provided. It was also found in 2002 at vernal pool  
16 complex northeast of Shippee and northwest of Thermalito Forebay, and one individual was reported  
17 from Bidwell Park in 2003 (CNDDDB 2006) (Figure A-25).

### 18 **A.25.3 Habitat Requirements and Special Considerations**

19 Vernal pool tadpole shrimp typically inhabit vernal pools containing clear to highly turbid water,  
20 although the species may occur in a variety of natural and artificial ephemeral wetland habitats,  
21 such as ephemeral drainages, stock ponds, reservoirs, ditches, backhoe pits, and ruts caused by  
22 vehicular activities. None are known to occur in running or marine waters or other permanent  
23 bodies of water (USFWS 1994, 2002, 2005). Vernal pool tadpole shrimp are sporadic in their  
24 distribution, often inhabiting only one or a few vernal pools in otherwise more widespread pool  
25 complexes. Pools within a complex typically are separated by distances on the order of meters and  
26 may form dense, interconnected mosaics of small pools or a sparser scattering of larger pools  
27 (USFWS 2002). The species has been collected in vernal pools ranging from 2 to 356,253 square  
28 meters (6.5 square feet to 88 acres) in surface area. Some of these vernal pools may be too small to  
29 remain inundated for the entire life cycle of the tadpole shrimp, but the vernal pool tadpole shrimp  
30 may be able to tolerate temporary drying conditions. Vernal pool tadpole shrimp have been found  
31 in pools with water temperatures ranging from 50°F (10°C) to 84°F (29°C) and pH ranging from  
32 6.2 to 8.5; however, vernal pools exhibit daily and seasonal fluctuations in pH, temperature,  
33 dissolved oxygen, and other water chemistry characteristics. Determining the vernal pool tadpole  
34 shrimp's habitat requirements is not possible based on anecdotal evidence, and the tolerances of  
35 this species to specific environmental conditions have yet to be determined (USFWS 2005).  
36 Vernal pools with vernal pool tadpole shrimp are most commonly located in grass bottomed swales  
37 of grasslands in old alluvial soils underlain by hardpan or in mud-bottomed pools containing  
38 highly turbid water (USFWS 1994).



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**Figure A-25. Vernal Pool Tadpole Shrimp Modeled Habitat and Recorded Occurrences**

3

1 **Community Associations.** The vernal pool tadpole shrimp occupy the same vernal pool habitats as  
2 many of the other vernal pool species, including several other rare and endangered vernal pool  
3 crustacean (USFWS 2005). In Butte County, plant species that have been found in the same vernal  
4 pool habitats as the vernal pool tadpole shrimp include blennosperma (*Blennosperma nanum*),  
5 coyote thistle (*Eryngium vaseyi*), and goldfields (*Lasthenia* sp.) (CNDDDB 2006).

#### 6 **A.25.4 Life History**

7 Vernal pool tadpole shrimp are ecologically dependent on seasonal fluctuations in their habitat,  
8 such as absence or presence of water during specific times of the year, duration of inundation,  
9 and other environmental factors that include specific salinity, conductivity, dissolved solids, and  
10 pH levels (USFWS 2002). Although the vernal pool tadpole shrimp is adapted to survive in  
11 seasonally available habitat, the species has a relatively long lifespan compared to other vernal  
12 pool crustaceans. Vernal pool tadpole shrimp continue growing throughout their lives,  
13 periodically molting their shells, which can often be found in vernal pools where this species  
14 occurs. Vernal pool tadpole shrimp take a minimum of 25 days to mature, and the mean age at  
15 first reproduction is 54 days. Other researchers have observed that vernal pool tadpole shrimp  
16 generally take between 3 and 4 weeks to mature and found that reproduction did not begin until  
17 individuals were larger than 10 millimeters (0.4 inch) in carapace length. Variation in growth  
18 and maturation rates may be a result of differences in water temperature, which strongly  
19 influences the growth rates of aquatic invertebrates (USFWS 2005).

20 Vernal pool tadpole shrimp have relatively high reproductive rates and also may be  
21 hermaphroditic. Sex ratios can also vary, perhaps in response to changes in water temperature.  
22 After winter rains fill their vernal pool habitats, dormant vernal pool tadpole shrimp cysts may  
23 hatch in as little as 4 days. Additional cysts produced by adult tadpole shrimp during the wet  
24 season may hatch without going through a dormant period (USFWS 2005). Vernal pool tadpole  
25 shrimp emerge from their cysts as metanauplii, a stage that lasts for 1.5 to 2 hours. Then they  
26 molt into a larval form resembling the adult. Multiple hatching within the same wet season  
27 allows vernal pool tadpole shrimp to persist within vernal pools as long as these habitats remain  
28 inundated, sometimes for 6 months or more. Vernal pool tadpole shrimp hatching is temperature  
29 dependent, with optimal hatching between 50 to 59°F (10 to 15°C), and hatching rates becoming  
30 significantly lower at temperatures above 68°F (20°C) (USFWS 2005).

31 **Population Structure.** Genetic variation among vernal pool tadpole shrimp was studied in  
32 populations at 20 different sites in the Central Valley. The results found that 96 percent of the  
33 genetic variation measured was due to differences between sites. This result corresponds with  
34 the findings of other researchers that vernal pool crustaceans have low rates of gene flow  
35 between separated sites. The low rate of exchange between vernal pool tadpole shrimp  
36 populations is probably a result of the spatial isolation of their habitats and their reliance on  
37 passive dispersal mechanisms. However, the studies also found that gene flow between pools  
38 within the same vernal pool complex is much higher. This indicates that vernal pool tadpole

1 shrimp populations, like most vernal pool crustacean populations, are defined by vernal pool  
2 complexes and not by individual vernal pools (USFWS 2005).

### 3 **A.25.5 Threats**

4 Threats to vernal pool habitat, and vernal pool species in general (including vernal pool tadpole  
5 shrimp), were identified in the Recovery Plan (USFWS 2005). In addition, the Recovery Plan  
6 identified several threats specific to the vernal pool tadpole shrimp.

#### 7 **A.25.5.1 Habitat Loss and Fragmentation**

8 Habitat loss and fragmentation were identified as the largest threats to the survival and recovery  
9 of vernal pool species. Habitat loss is generally a result of urbanization, agricultural conversion,  
10 and mining and can also occur as a result of habitat alteration and degradation due to changes to  
11 natural hydrology, invasive species, incompatible grazing regimes (including insufficient grazing  
12 for prolonged periods), infrastructure projects (such as roads and utility projects), recreational  
13 activities (such as off-road vehicles and hiking), erosion, climatic and environmental change, and  
14 contamination. Habitat fragmentation is also related to habitat loss when individual vernal pools  
15 become disconnected and isolated as a result of result of activities such as road development and  
16 other infrastructure projects. Widespread urbanization and the construction of infrastructure are  
17 major contributors to the loss of vernal pool habitats and their associated species. In addition,  
18 gravel and clay mining operations that are needed to support urban development, including roads  
19 and other infrastructure, have resulted in the destruction of vernal pools (USFWS 2005, 2006b).

20 The CNDDDB lists numerous occurrences of vernal pool tadpole shrimp as threatened by  
21 development and agricultural conversions throughout its range. In the Northeastern Sacramento  
22 Valley Vernal Pool Region, several of the known occurrences of the vernal pool tadpole shrimp  
23 are located on Caltrans rights-of-way and are threatened by future road improvement projects in  
24 this region (USFWS 2005). In Butte County, 10 of the 18 locations where vernal pool tadpole  
25 shrimp have been recorded, including several larger vernal pool complexes, are within the  
26 Caltrans right-of-way along Highways 99 and 149 and could be threatened by future expansion  
27 of these roads. Seven known occurrences in Butte County are on private property or the  
28 owner/manager is unknown, including one in The Nature Conservancy's Vina Plains Preserve.  
29 One occurrence is in Bidwell Park, which is owned/managed by the City of Chico (CNDDDB  
30 2006).

#### 31 **A.25.5.2 Agricultural Conversion and Incompatible Livestock Grazing Practices**

32 Land use conversion, such as from grasslands or pastures, to more intensive agricultural uses,  
33 such as croplands or from one crop type to another, has contributed and continues to contribute  
34 to the decline of vernal pools in general. Although not identified as the primary threat to the  
35 vernal pool tadpole shrimp populations in Butte County, changes in grazing practices could alter  
36 the vernal pool habitat making it unsuitable for this species (USFWS 2005).

### 1 **A.25.5.3 Competition from Invasive Species**

2 Vernal pool plant species have declined due to the introduction of invasive, nonnative plant and  
3 animal species. Waxy managrass (*Glyceria declinata*), an invasive aquatic grass (Gerlach et al.  
4 2009), greatly increases the amount of decomposing biomass in vernal pools and may result in  
5 higher respiratory oxygen consumption relative to photosynthetic oxygen generation (Rogers  
6 1998). In addition, upland biomass of invasive species such as medusahead (*Taeniatherum*  
7 *caput-medusae*) can produce dense vegetation and thatch, shortening the ponding duration of  
8 some pools (Marty 2004, Pyke and Marty 2005). Increasing dominance by competitors may also  
9 contribute to changes in hydrology and livestock grazing practices. Introduction of the bullfrog  
10 (*Rana catesbeiana*), a voracious predator on many species of native and nonnative animals, to  
11 areas inhabited by the vernal pool tadpole shrimp appears to be a threat to this species where  
12 perennial water bodies suitable for bullfrog breeding are near seasonal water bodies suitable for  
13 shrimp (USFWS 2002). Vernal pool tadpole shrimp are known to have been parasitized by  
14 flukes (Trematoda) of an undetermined species at the Vina Plains Preserve, Tehama County,  
15 which may be a limiting factor affecting reproduction of this species in this area. In addition,  
16 vernal pool tadpole shrimp are threatened by the encroachment of nonnative annual grasses on  
17 the San Francisco Bay National Wildlife Refuge (USFWS 2005).

### 18 **A.25.5.4 Altered Hydrology**

19 Changes in hydrology that result in a change in the timing, frequency, and duration of inundation  
20 in vernal pools can create conditions that render existing vernal pools unsuitable for vernal pool  
21 species (USFWS 2005). The vernal pool complexes in areas proposed for road improvements  
22 could be affected by alteration of hydrology which could diminish habitat for vernal pool tadpole  
23 shrimp (CNDDDB 2006).

### 24 **A.25.5.5 Contamination**

25 Slight changes in water chemistry directly affect sensitive vernal pool species, especially vernal  
26 pool crustaceans. Water contamination can occur from herbicides, fertilizers, and other  
27 chemicals commonly used in urban and agricultural settings. Pesticide applications for  
28 combating West Nile virus, a disease transmitted by infected mosquitoes, may also affect fairy  
29 shrimp species. Fertilizers may also contribute to the growth of invasive plants (USFWS 2005).  
30 Vernal pool tadpole shrimp populations on the Stone Corral Ecological Reserve in Tulare  
31 County may be threatened by pesticide drift from adjacent farmlands.

### 32 **A.25.5.6 Other Threats**

33 Several other threats to vernal pools and their associate species in general were identified in the  
34 Recovery Plan. Although not specifically identified as a threat to vernal pool tadpole shrimp,  
35 these threats contribute to the decline of vernal pool habitats, which will affect all species that  
36 are dependent on functional vernal pool habitats for survival. Human use and recreational  
37 activities, such as off-road vehicle use, hiking, and bicycling, threaten vernal pool ecosystems.

1 When access is through vernal pool complexes, hydrological functions may be impaired by  
2 displaced soil causing erosion or interrupting swale connectivity. Also, off-road enthusiasts,  
3 such as bicyclists, may create dirt jump ramps, which also could result in the burial of seeds and  
4 cysts of plants and animals or soil compaction. Recreational users also may introduce, or  
5 facilitate spread of, invasive plants or dispose waste and debris into vernal pool habitat and alter  
6 the ecology (USFWS 2005).

7 Habitat alteration may also occur due to large-scale climate and environmental changes, such as  
8 global warming, which lead to changes in the precipitation pattern and atmospheric conditions.  
9 Most of the populations of vernal pool tadpole shrimp are isolated from other populations and  
10 are distributed in discontinuous vernal pool systems; small, isolated populations are vulnerable,  
11 which could result in extirpation from a particular area (USFWS 2005, 2006b).

## 12 **A.25.6 Relevant Conservation Efforts**

13 The vernal pool tadpole shrimp is protected as a threatened species under the Endangered  
14 Species Act. In the Northeastern Sacramento Valley region, vernal pool tadpole shrimp are  
15 protected on a private mitigation area and on land owned by The Nature Conservancy (USFWS  
16 2005, CNDDDB 2006).

17 Although conservation efforts have been taken for vernal pool ecosystems in general, very few  
18 actions have been taken specifically to benefit the vernal pool tadpole shrimp. An example of  
19 one of these actions is a grazing program at the Stone Corral Ecological Reserve for the benefit  
20 of vernal pool crustaceans that is being monitored by California Department of Fish and Game  
21 staff (USFWS 2005).

## 22 **A.25.7 Species Habitat Suitability Model**

### 23 **A.25.7.1 Habitat**

24 Vernal pool tadpole shrimp habitat includes the following BRCP mapped land cover types:

- 25 • Vernal pool;
- 26 • Altered vernal pool; and
- 27 • Grassland with vernal swale complex.

28 Vernal pools that may support vernal pool tadpole shrimp habitat may also occur as inclusions in  
29 mapped grassland, blue oak savanna, ranchettes–open, and disturbed ground land cover types.  
30 These inclusions were not mapped because they did not meet the mapping criteria for vernal  
31 pool, altered vernal pool, and grassland with vernal swale complex land cover types.

32

### 1 **A.25.7.2 Assumptions**

2 The vernal pool tadpole shrimp is found only in ephemeral freshwater habitats, including  
3 alkaline pools, clay flats, vernal lakes, vernal pools, vernal swales, and other seasonal wetlands  
4 (USFWS 2007). Vernal pool tadpole shrimp typically inhabit vernal pools containing clear to  
5 highly turbid water, although the species may occur in a variety of natural and artificial  
6 ephemeral wetland habitats, such as ephemeral drainages, stock ponds, reservoirs, ditches,  
7 backhoe pits, and ruts caused by vehicular activities (USFWS 2006). None are known to occur  
8 in running or marine waters or other permanent bodies of water (USFWS 2005). The species has  
9 been collected in vernal pools ranging from 6.5 square feet to 88 acres (USFWS 2005).

10 Given these habitat preferences, suitable habitat for the vernal pool tadpole shrimp is defined as  
11 any vernal pool, altered vernal pool, and grassland with vernal swale complex within the Plan  
12 Area.

### 13 **A.25.8 Recovery Plan Goals**

14 A general statement for recovery of vernal pool tadpole shrimp is presented in the Recovery  
15 Plan: to ensure protection of the full geographic, genetic and ecological extent of this species and  
16 to improve the circumstances that caused it to be listed in the first place. Accomplishment of this  
17 goal would be achieved by protecting 80 percent of this species existing occurrences and 100  
18 percent of reintroduced populations throughout its range. Ninety-five percent of this species  
19 suitable habitat is to be protected within 13 Core Areas, including Chico, Oroville and Vina  
20 Plains in the Northeast Sacramento Valley Vernal Pool Region, which included Butte County,  
21 and 85 percent of suitable habitat in 11 Core Areas, including Dales and Doe Mill in the  
22 Northeast Sacramento Valley Vernal Pool Region. In addition, the species would be  
23 reintroduced into vernal pool regions and soil types from which surveys indicate that it has been  
24 eradicated (USFWS 2005).

### 25 **A.25.9 References**

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