

San Diego Fairy Shrimp
(Branchinecta sandiegonensis)

5-Year Review:
Summary and Evaluation

[Cover illustration to be inserted later]

U.S. Fish and Wildlife Service
Carlsbad Office
Carlsbad, California

September 2008

5-YEAR REVIEW

San Diego Fairy Shrimp (*Branchinecta sandiegonensis*)

I. GENERAL INFORMATION

Purpose of 5-Year Reviews:

The U.S. Fish and Wildlife Service (Service) is required by section 4(c)(2) of the Endangered Species Act (Act) to conduct a status review of each listed species at least once every 5 years. The purpose of a 5-year review is to evaluate whether or not the species' status has changed since it was listed (or since the most recent 5-year review). Based on the 5-year review, we recommend whether the species should be removed from the list of endangered and threatened species, be changed in status from endangered to threatened, or be changed in status from threatened to endangered. Our original listing of a species as endangered or threatened is based on the existence of threats attributable to one or more of the five threat factors described in section 4(a)(1) of the Act, and we must consider these same five factors in any subsequent consideration of reclassification or delisting of a species. In the 5-year review, we consider the best available scientific and commercial data on the species, and focus on new information available since the species was listed or last reviewed. If we recommend a change in listing status based on the results of the 5-year review, we must propose to do so through a separate rule-making process defined in the Act that includes public review and comment.

Species Overview:

The San Diego fairy shrimp (*Branchinecta sandiegonensis*) is a small aquatic crustacean generally restricted to vernal pools in coastal southern California and northwestern Baja California, Mexico. San Diego fairy shrimp are usually observed from January to March when seasonal rainfall fills vernal pools and initiates cyst (egg) hatching.

Methodology Used to Complete This Review:

This review was prepared by the Carlsbad Fish and Wildlife Office of the U.S. Fish and Wildlife Service. For this review, we considered the Recovery Plan for Vernal Pools of Southern California (Service 1998a); The U.S. Fish and Wildlife Service Vernal Pool Crustacean 5-Year Status Review, San Diego fairy shrimp, Final Draft (ESA Associates 2007); office files; available literature; new survey information; and interviews of individuals involved with surveying, research, and management of San Diego fairy shrimp. Additionally, we contacted the Ventura Fish and Wildlife Office for information regarding the status of this species within its area of jurisdiction.

Contact Information:

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Cooperating Field Office(s): Julie Vanderwier, Fish and Wildlife Biologist, Ventura Fish and Wildlife Office; (805) 644-1766

Federal Register (FR) Notice Citation Announcing Initiation of This Review: A notice announcing initiation of the 5-year review of this taxon and the opening of a 60-day period to receive information from the public was published in the Federal Register on March 22, 2006; 71 FR 14538. We received 3 letters regarding this 5-year review. Relevant information provided by these letters has been included in the review.

Listing History:

Original Listing

FR Notice: 62 FR 4925

Date of Final Listing Rule: February 3, 1997

Entity Listed: Fairy shrimp, San Diego (*Branchinecta sandiegonensis*), an invertebrate species

Classification: endangered

Associated Rulemakings:

Original Proposed Critical Habitat

FR Notice: 65 FR 12181

Date of Proposed Critical Habitat Rule: March 8, 2000

Final Critical Habitat

FR Notice: 65 FR 63438

Date of Final Critical Habitat Rule: October 23, 2000

Proposed Revision to Critical Habitat

FR Notice: 68 FR 19888

Date of Proposed Revised Critical Habitat Rule: April 22, 2003

Final Revision to Critical Habitat

FR Notice: 72 FR 70648

Date of Final Revised Critical Habitat Rule: December 12, 2007

Review History: No previous 5-year reviews have been completed for San Diego fairy shrimp.

Species' Recovery Priority Number at Start of 5-Year Review: The recovery priority number for *Branchinecta sandiegonensis* is 2C according to the Service's 2007 Recovery Data Call for the Carlsbad Fish and Wildlife Office, based on a 1-18 ranking system where 1 is the highest-ranked recovery priority and 18 is the lowest (Endangered and Threatened Species Listing and Recovery Priority Guidelines, 48 FR 43098, September 21, 1983). This number indicates that

the taxon is a species that faces a high degree of threat and has a high potential for recovery. The “C” indicates conflict with construction, other development projects, or other forms of economic activity.

Recovery Plan or Outline

Name of Plan or Outline: Recovery Plan for Vernal Pools of Southern California

Date Issued: September 3, 1998

II. REVIEW ANALYSIS

Application of the 1996 Distinct Population Segment (DPS) Policy

The Endangered Species Act defines “species” as including any subspecies of fish or wildlife or plants, and any distinct population segment (DPS) of any species of vertebrate wildlife. This definition of species under the Act limits listing as distinct population segments to species of vertebrate fish or wildlife. Because the species under review is an invertebrate, the DPS policy is not applicable, and the application of the DPS policy to the species’ listing is not addressed further in this review.

Information on the Species and its Status

Species Description

The San Diego fairy shrimp (*Branchinecta sandiegonensis*) is a small aquatic crustacean in the order Anostraca, first described in 1993 by Michael Fugate (1993) based on collections from Del Mar Mesa in San Diego County. Male San Diego fairy shrimp are distinguished from other *Branchinecta* species males by differences in the distal (i.e., located far from the point of attachment) tip of the second antennae. The females carry their cysts (i.e., eggs) in an oval or elongate ventral (i.e., located toward the underside) brood sac (Eriksen and Belk 1999). Females are distinguishable from other *Branchinecta* species females by the shape and length of the brood sac, length of the ovary, and presence of paired dorsolateral (i.e., located on the sides, toward the back) spines on five of the abdominal segments (Fugate 1993). The San Diego fairy shrimp is often misidentified with the versatile fairy shrimp (*Branchinecta lindahli*) (Fugate 1993), which is native to and commonly found throughout western North America (Eng et al. 1990, Simovich 1998).

Species Biology and Life History

San Diego fairy shrimp are generally restricted to vernal pools and other non-vegetated ephemeral (i.e., containing water a short time) basins 2 to 12 inches in depth in coastal southern California and northwestern Baja California, Mexico (Simovich and Fugate 1992; Hathaway and Simovich 1996). San Diego fairy shrimp cysts cannot hatch in perennial (i.e., containing water year round) basins because the re-wetting of dried cysts is one component of a set of environmental stimuli that trigger hatching (Eriksen and Belk 1999) (temperature is another

important cue; water chemistry and other factors may also play a role (Eriksen and Belk 1999; Hathaway and Simovich 1996; Simovich and Hathaway 1997)).

San Diego fairy shrimp feed on algae, diatoms, and particulate organic matter (Parsick 2002). San Diego fairy shrimp are usually observed from January to March when seasonal rainfall fills vernal pools and initiates cyst hatching (vernal pools in southern California typically contain water in the winter and then are dry in the summer). Individuals hatch and mature within 7 to 14 days of rainfall filling a pool depending on water temperature (Hathaway and Simovich 1996; Simovich and Hathaway 1997). This hatching period may be extended in years with early or late rainfall.

Cysts produced from successful reproduction are either dropped to the pool bottom or remain in the brood sac until the female dies and sinks. Cysts are capable of withstanding temperature extremes and prolonged drying. Only a portion of the cysts may hatch when pools refill in the same or subsequent rainy seasons; therefore, cyst “banks” develop in pool soils that are composed of cysts from several years of breeding. This partial hatching of cysts allows the San Diego fairy shrimp to persist in its extremely variable environment, since pools commonly fill and dry before hatched individuals can reproduce, and if all cysts hatched during an insufficient filling the species could be extirpated from a pool (Philippi et al. 2001, Simovich 2005a, Simovich and Hathaway 1997). The ability of San Diego fairy shrimp to develop and maintain cyst banks is vital to the long-term survival of San Diego fairy shrimp populations (Ripley et al. 2004, Simovich 2005a).

Spatial Distribution

The February 3, 1997, listing rule states that San Diego fairy shrimp were known to inhabit a minimum of 25 vernal pool complexes in coastal areas of San Diego, Orange, and Santa Barbara counties, and northwestern Baja California, Mexico (62 FR 4925)¹. However, the names and locations of all complexes were not specified in the listing rule and therefore it is difficult to ascertain the status of these complexes. Currently, 137 complexes occupied by San Diego fairy shrimp have been identified in the U.S.; an additional 3 complexes that were identified as occupied at listing have since been extirpated (Appendix 1). Most of these additional complexes fall within the extant range of the San Diego fairy shrimp known at the time of listing. We expect that these additional complexes and occurrences were occupied at the time of listing, but had not been identified due to lack of survey effort, and do not represent an actual expansion of San Diego fairy shrimp distribution and range into previously unoccupied areas. Rather, they provide a better understanding of the historical distribution and range of the San Diego fairy shrimp that was unknown at the time of listing. Therefore, we estimate that the overall San Diego fairy shrimp distribution has not decreased or increased appreciably since listing. The current San Diego fairy shrimp distribution is shown in Figure 1 below. A summary of occupied vernal pool complexes is provided in Table 1; these complexes are detailed in Appendix 1 as well.

¹ Vernal pool complexes are defined as a series of vernal pool groups that are hydrologically connected with similar species compositions.

Figure 1. Current distribution of San Diego fairy shrimp (from Service files, Carlsbad Fish and Wildlife Office, 2008).

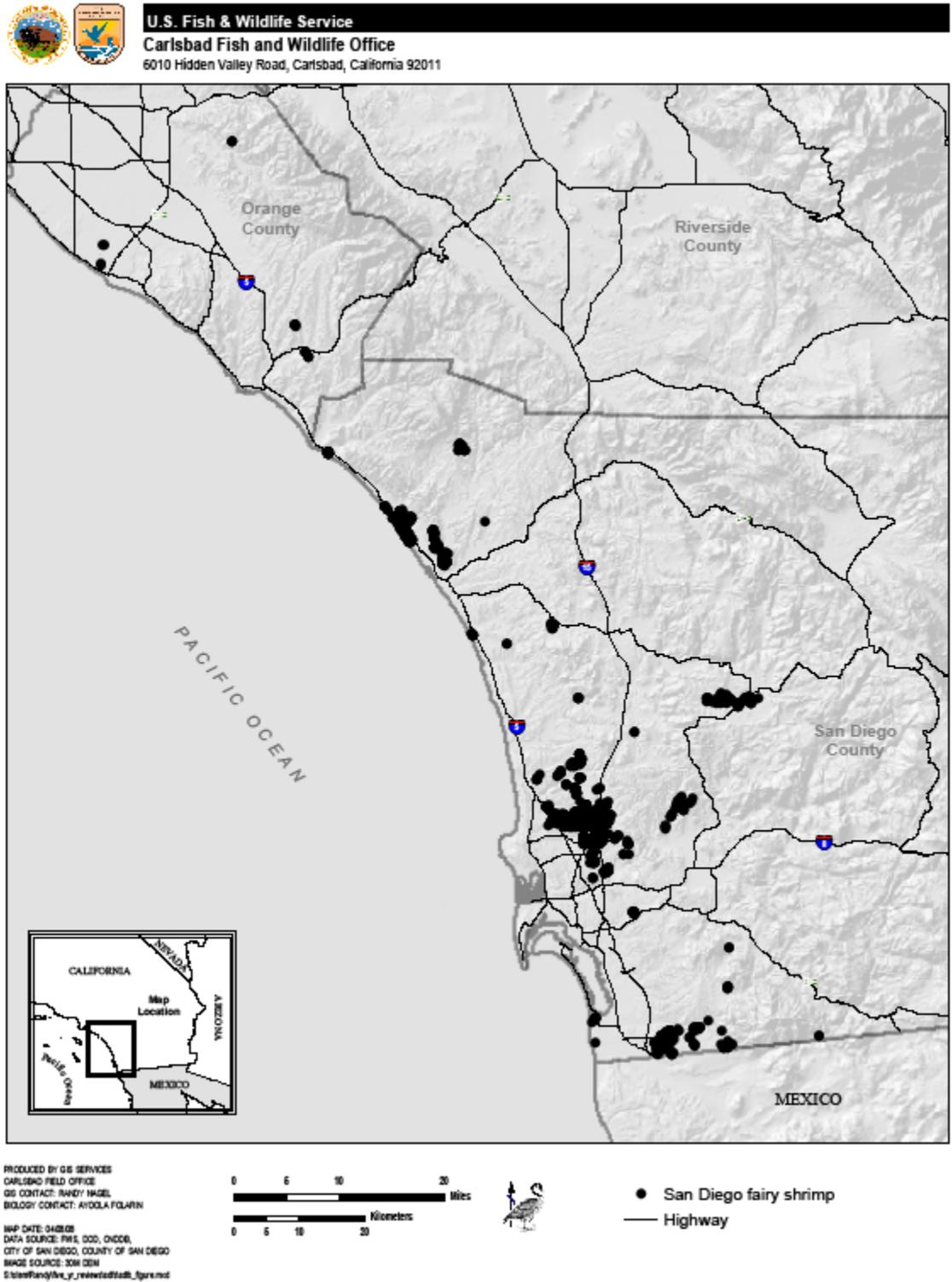


Table 1. San Diego fairy shrimp occurrences identified at listing in 1997 (62 FR 4925) and since listing (Service files, Carlsbad Fish and Wildlife Office, 2008).

Geographic Area	Number of Complexes
Orange County	5
San Diego County	
Marine Corps Base (MCB) Camp Pendleton	9
San Marcos	4
Carlsbad	3
Ramona	9
Santa Fe Valley	1
Poway	1
Del Mar Mesa, Lopez Ridge, and Mira Mesa	20
Santee*	3
Mission Trails Regional Park	1
Kearny Mesa	53
Chollas Heights	1
Sweetwater Reservoir*	1
Marron Valley*	1
Otay Mesa	23
Tijuana Slough National Wildlife Refuge	1
Imperial Beach*	1
Baja California (Mexico)	1
Total Complexes Identified Since Listing	approximately 113
Complexes Identified at Listing	approximately 25
Complexes Extirpated Since Listing	3
Overall Total of Extant Complexes (in the U.S.)	137

* No occurrences were known in this area at the time of listing.

Adequately quantifying occurrence and distribution of the San Diego fairy shrimp is difficult due to a number of factors. First, vernal pools are generally too small to appear on topographic maps (Holland 1978) and therefore difficult to identify, and San Diego fairy shrimp are restricted to certain pool types within a narrow geographic region (Hathaway and Simovich 1996). Second, not all vernal pools fill in a given year, and pools may not fill long enough for hatching (i.e., discovery) of the San Diego fairy shrimp. And finally, in any given pool that has retained water long enough to hatch San Diego fairy shrimp, surveys may miss collecting adults simply due to their low hatching percent (i.e., as few as 6 percent; Simovich and Hathaway 1997). Thus, once vernal pools are identified, surveys may not detect individuals in a particular year even when viable cysts are present.

Abundance

Surveying populations for changes in numbers of individuals and demographic trends over time is not possible due to the small size and life history traits of San Diego fairy shrimp. However, research into the development of population assessment methods is being pursued (see “Species-specific Research and/or Grant-supported Activities” section below). Population trends are determined indirectly by assessing changes in the amount of habitat occupied by the species over time. An estimated minimum of 25 vernal pool complexes occupied by San Diego fairy shrimp were known at the time of listing in 1997. Although there are more known occupied complexes now (137) than were known at the time of listing (25), we believe that the additional occupied complexes were likely in existence (though undocumented) when the species was listed. Approximately 28 occupied vernal pool complexes of the total 137 have been partially lost due to development (Appendix 1) and only 3 complexes are known to have been permanently lost to development since listing (i.e., Antonio Parkway in southwestern Orange County (Service 1996a); Ramona Post Office in the City of Ramona, San Diego County (Service 1997a); and J1 (Calterracas) in Otay Mesa, San Diego County (Service 1997b)). However, losses due to development have been offset via vernal pool restoration (i.e., the re-establishment of functional vernal pool ecosystems in areas that once supported vernal pools, but which have been impacted to the extent that they no longer exhibit the physical and biological attributes of a vernal pool ecosystem), and preservation (e.g., the physical and legal protection of existing vernal pool basins) and enhancement (e.g., removal of trash, control of nonnative plants, reintroduction of San Diego fairy shrimp where appropriate, etc.) of preserved pools through consultations under section 7 and section 10 of the Act. Additionally, the species has been reintroduced into numerous vernal pools as part of vernal pool restoration projects where appropriate² (see section 7 consultations cited in Appendix 1). Therefore, we estimate that San Diego fairy shrimp abundance has not increased or decreased substantially since listing, because the additional occupied complexes identified since listing were likely in existence (though undocumented) when the species was listed.

Habitat or Ecosystem

San Diego fairy shrimp occur in groups of vernal pools referred to as vernal pool complexes (Keeler-Wolf et al. 1998). Vernal pool complexes tend to average between 5 and 50 vernal

² Monitoring of projects to verify successful restoration and establishment of San Diego fairy shrimp cyst banks is ongoing.

pools, although some contain as few as two vernal pools and others contain several hundred vernal pools. Vernal pools within a complex are generally hydrologically connected, such that water flows over the surface from one vernal pool to another and/or water flows and collects below ground such that the soil becomes saturated with water, thus filling the vernal pool with water (Hanes et al. 1990). For this reason, vernal pool complexes are best described from a watershed perspective (Service 1998a). The vernal pool watershed includes all areas around a vernal pool complex needed to collect rainfall and adequately fill the vernal pools within the complex. Vernal pools begin to fill following the onset of fall and winter rains. Some pools in a complex have substantial watersheds that contribute to filling the vernal pools, while others fill almost entirely from rainfall (Hanes et al. 1990; Hanes and Stromberg 1998). Additionally, subsurface inflows from surrounding soils may be an important factor in filling some vernal pools (Hanes et al. 1990; Hanes and Stromberg 1998). San Diego fairy shrimp are restricted to dilute vernal pools, having relatively low sodium (Na^+) concentrations (below 60 millimoles per liter), low alkalinity (below 1000 milligrams per liter), and neutral pH (near 7) (Gonzales et al. 1996). Gonzales et al. (1996) found the species was unable to regulate internal ion levels and mortality increased at higher Na^+ concentrations and alkalinity.

A number of other flora and fauna species are known to inhabit vernal pool complexes in southern California. Several plant genera are endemic to California vernal pool habitats (e.g., *Pogogyne*, *Downingia*, *Psilocarphus*, *Orcuttia*) (Thorne 1984). Vegetation communities associated with adjacent upland habitats that surround the vernal pools in southern California are valley needlegrass grassland, annual grasslands, coastal sage scrub, maritime succulent scrub, and chaparral (Keeler-Wolf et al. 1998). Some animal species that use vernal pools, such as spadefoot toads (*Scaphiopus hammondi*) and Pacific tree frogs (*Hyla regilla*), spend a large portion of their life cycle in the adjacent soils and vegetation, but require ponding water to breed (Simovich 1985). Vernal pools are also used by birds and various mammals for food, water, and nesting. Finally, San Diego fairy shrimp and other invertebrates provide food for waterfowl (especially ducks) (Krapu 1974; Proctor 1964; Swanson et al. 1974; Silveira 1998), as well as western spadefoot toad tadpoles (Branchiopod Research Group 1996).

Changes in Taxonomic Classification or Nomenclature

No changes in taxonomic classification or nomenclature have occurred since listing.

Genetics

A recent mitochondrial DNA (i.e., genetic sequence of maternally-inherited DNA located outside the cell nucleus) study sampled 316 San Diego fairy shrimp from 24 vernal pool complexes (Bohonak 2005). Researchers identified 50 unique alleles (i.e., different forms of a gene); each unique allele was found only at specific vernal pool complexes or within isolated geographic areas (Bohonak 2005). Bohonak (2005) identified two distinct genetic clades (i.e., genetically related groups within a taxon) among all sampled San Diego fairy shrimp locations, referred to as Group A and Group B. Bohonak states, “individuals from Group A and B have been isolated from one another biologically for tens of thousands or perhaps millions of years with little or no dispersal or hybridization.” The distribution of the two clades is unusual because one would expect them to be geographically separate; however, the two clades are somewhat intermixed

geographically. The San Diego fairy shrimp from southern and northern City of San Diego and central eastern Orange County are in Group A; and those from central City of San Diego, and eastern and northern San Diego County, are in Group B. With the exception of the geographically intermixed nature of the two clades, San Diego fairy shrimp within a vernal pool complex or limited geographic area were found to be generally more closely related to each other than to those at more distant locations. Additionally, Bohonak's results indicate that gene flow between pool complexes is lower in areas that have less disturbance from urbanization and human activities. Bohonak (2005) postulated that human activities tend to homogenize (i.e., render uniform or similar) the genetic composition of natural populations of the species by translocating cysts between pool complexes. It is not known what effect this suspected human-related homogenization may have on the long-term viability of San Diego fairy shrimp. More genetic research on San Diego fairy shrimp is needed to complete our understanding of the genetic dynamics and distribution of the species.

Species-specific Research and/or Grant-supported Activities

A project was funded by a Service/U.S. Geological Survey Quick Response Grant in 2007 to develop a protocol for extracting DNA from fairy shrimp cysts, and use the extracted genetic material to identify the fairy shrimp cysts to species. The investigation was carried out by Amy Vandergast, Ph.D., and Robert N. Fisher, Ph.D., U.S. Geological Survey; Andrew J. Bohonak, Ph.D., San Diego State University; and Marie Simovich, Ph.D., University of San Diego. The researchers developed a polymerase chain reaction (PCR) method (i.e., a DNA extraction method by which a few fragments of DNA can be duplicated into millions in a couple of hours) that can successfully differentiate between different species of fairy shrimp. Two manuscripts detailing the work funded by this grant have been submitted to the *Journal of Crustacean Biology*, a peer-reviewed scientific publication.

The genetic study discussed in the "Genetics" section of this review was funded by the Service through the City of San Diego Multiple Species Conservation Program.

A project has been funded by a Service Endangered Species Act section 6 grant to develop a protocol to estimate San Diego fairy shrimp population sizes and conduct population viability analyses in real time, in order to detect a decline preceding the likely extinction of a population. Implementation of this recovery action is necessary to better understand and hence ameliorate the threats that may lead to extinction. The investigation will be carried out by Andrew J. Bohonak, Ph.D., San Diego State University; and Marie Simovich, Ph.D., University of San Diego, and their laboratory assistants.

A study done by the U.S. Marine Corps looking at the effects of fire on vernal pools on Marine Corps Air Station (MCAS) Miramar found no apparent negative effects on fairy shrimp in the 3 years following a 2000 wildfire (MCAS Miramar 2005). Vernal pool hydrology did not appear to be affected in the MCAS Miramar study (MCAS Miramar 2005), and nonnative plant cover in burned pools was significantly lower than in control pools that had not burned. The Marine Corps is continuing to investigate the effects of fire on vernal pools.

The Marine Corps has initiated a study on Marine Corps Base (MCB) Camp Pendleton to evaluate the impact of tracked vehicle training on fairy shrimp (see the “Military Activities” section under “Factor A” below). Results of this study are not yet available.

FIVE-FACTOR ANALYSIS

The following five-factor analysis describes and evaluates the threats attributable to one or more of the five listing factors outlined in section 4(a)(1) of the Act. Although we believe that all 137 known extant complexes were likely occupied at the time of listing, the listing rule analyzed threats in the context of approximately 25 known occupied complexes. Our current analysis examines all known occupied habitat.

FACTOR A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range

At the time of listing in 1997, the San Diego fairy shrimp was imperiled because the habitat on which the species is dependant, vernal pools, and the watersheds that sustain vernal pools, was being damaged or destroyed by a variety of human-caused activities, primarily urban development and agricultural conversion (62 FR 4925). It was estimated that 90 to 97 percent of its historical habitat in San Diego County had been destroyed (Bauder 1986a, Oberbauer and Vanderwier 1991; Keeler-Wolf et al. 1995) and that similar declines had occurred elsewhere (Keeler-Wolf et al. 1995; Ferren and Pritchett 1988). The listing rule states that remaining vernal pools were vulnerable to one or more of the following habitat disturbances: development, runoff and other alterations in hydrology, agriculture, grazing and cattle trampling, and military activities; off-highway vehicle (OHV) use is another habitat disturbance that is further discussed under Factor E (“Human Access and Disturbance”). The current magnitude of these and other threats to vernal pools and their watersheds throughout the range of the species are discussed below.

Development

At listing, development was characterized as the most significant threat to San Diego fairy shrimp habitat across its range. San Diego is one of the fastest growing counties in the nation, and is estimated to have a population of approximately 3.6 million people by the year 2020 (California Department of Finance 2004), approximately 16 percent more than the estimated January 1, 2007, population of 3,098,269 (San Diego Association of Governments 2007). The adjacent Orange County (3,098,183 estimated January 1, 2007, population; California Department of Finance 2007), which also supports occurrences of San Diego fairy shrimp, is expected to grow by 23 percent between 2010 and 2020 (California Department of Finance 2004). These predicted growth rates suggest urban and commercial/industrial development pressures will continue to rise within the extant range of the San Diego fairy shrimp. Additionally, development of border security measures threatens San Diego fairy shrimp habitat along the international border with Mexico. Such development can result in direct impacts to San Diego fairy shrimp habitat, i.e., destruction of vernal pools or their watersheds, and isolation of pools and fragmentation of pool systems; development can also cause alterations in the hydrology of adjacent pools.

Habitat Loss

Habitat loss associated with development is the result of destruction and modification of vernal pools and their watersheds due to filling, grading, discing, leveling, and other activities. Because the species is dependant upon this specific habitat type for survival, habitat loss results in the mortality of San Diego fairy shrimp occupying the developed habitat. Since listing, Service files show that 3 complexes occupied by the San Diego fairy shrimp have been lost to development; of the remaining 137 occupied complexes, another 28 complexes have been partially lost to development, and about 5 contain pools that have been impacted (damaged, but not lost; many of the impacted pools have been restored) (Appendix 1). Most of these losses and impacts are the result of urban development, followed by industrial/commercial, international border security, and military training facilities, development, and infrastructure (Appendix 1). There are currently development proposals in place that would partially impact another 24 complexes (approximately) occupied by San Diego fairy shrimp; however, we expect that the effect of these future impacts to the species will be minimized through conservation measures, and terms and conditions, included in our biological opinions and incidental take statements.

The magnitude of the development threat has been lessened by the listing of the San Diego fairy shrimp and the designation of critical habitat for the species. Avoidance of occupied vernal pools is stressed when analyzing development projects with a Federal nexus during Endangered Species Act section 7 consultations. Impacts to San Diego fairy shrimp habitat are typically minimized through preservation and enhancement of existing pools, and/or restoration of basins in areas that once supported vernal pools. These efforts are often addressed as conservation measures included in the project description or otherwise included as terms and conditions of our biological opinions and incidental take statements to minimize the effects of take of San Diego fairy shrimp resulting from impacts to pools due to development. Vernal pool restoration projects are then maintained and monitored to ensure that efforts were successful. This maintenance and monitoring typically includes quantitative and qualitative assessments of progress toward specific project goals (e.g., number of vernal pools, pool area, acceptable percent coverage of desired species and nonnative plant species, presence of San Diego fairy shrimp, duration of ponding, water quality), and remediation of any issues that may arise. Although long-term monitoring and maintenance of these pools for other impacts (e.g., trash, damaged or removed fencing, trespassing) can be uncertain, we expect preserved and/or restored vernal pools will be protected from future development activities. Analysis of development projects covered by Habitat Conservation Plans (HCPs) under section 10 of the Endangered Species Act is discussed further under Factor D in the “Five-Factor Analysis” section of this review.

The long-term viability of restoration and preservation/enhancement projects has been called into question by some researchers familiar with the species and its habitat (e.g., Simovich 1998). It is possible that in some instances, San Diego fairy shrimp transplanted into restored pools do not form a viable cyst bank and over time may not

persist in the pools. Simovich (1998) recommends that quantitative and qualitative monitoring of restored vernal pools continue beyond 5 years to establish the success of restoration projects with certainty.

Despite the prohibition of take under section 9 of the Act and our efforts to minimize take through our consultation efforts, unauthorized habitat loss continues to occur within known occupied complexes, such as at the Arjons property in Kearny Mesa and the Habib complex in Ramona. Information in Service files indicates that the impacted pools on the Habib site have not been restored (though vegetation has been allowed to grow back) and are not being managed. Compensation for impacts at the Arjons property is recommended in the City of San Diego's Draft Vernal Pool Management Plan (2006), and has not yet been completed. These documented violations demonstrate that despite efforts made to offset development impacts, development projects continue to cause occasional unauthorized impacts to vernal pool habitat that may not be remediated.

In total, approximately 31 complexes on private lands are not preserved and are thus vulnerable to future development. These privately-owned lands support 23 percent of all known remaining occupied complexes. As demonstrated in Appendix 1, at least 13 of these complexes have been impacted in some way since this species was listed, and we anticipate impacts to 18 of these complexes in the near future based on project analyses and completed section 7 consultations. As the human population within the range of the San Diego fairy shrimp continues to grow, we expect the pressure to convert this species' habitat to development will increase. Although additional impacts to San Diego fairy shrimp habitat are likely to be minimized via avoidance and minimization measures, this endemic species remains vulnerable to impacts from development.

Habitat Isolation and Fragmentation

The listing rule for San Diego fairy shrimp identifies habitat isolation and fragmentation as a threat to the species. Fragmentation can isolate pools/complexes from upland habitats, which provide much of the San Diego fairy shrimp's food sources (algae, diatoms, and particulate organic matter brought into pools via overland flow of rainwater runoff). Because of the transportation of water, soil, minerals and nutrients over the landscape into vernal pools, the upland, or upslope areas associated with vernal pools are an important source of these for vernal pool organisms (Wetzel 1975). Since vernal pools are mostly rain-fed, they tend to have low nutrient levels (Keeley and Zedler 1998). In fact, most of the nutrients that vernal pool crustaceans derive from their vernal pool habitat come from the detritus (decaying organic matter) that washes into pools from the adjacent upslope areas; these nutrients provide the foundation for the food chain in the vernal pool aquatic community (Eriksen and Belk 1999), of which the fairy shrimp fauna constitutes an important component.

The Service encourages development projects to avoid isolating vernal pools or dividing complexes into ecologically separate fragments, and to configure new preserved/restored sites adjacent to and continuous with existing preserve areas. However often, pools are isolated and/or complexes fragmented regardless of Service recommendations.

Whenever vernal pools in a complex are impacted by development, some degree of fragmentation occurs within and among complexes. Fragmentation and associated impacts to hydrology continue to impact San Diego fairy shrimp habitat throughout its range.

Altered Hydrology

The final listing rule identified altered vernal pool hydrology as a significant threat to this species throughout its range. Development within a vernal pool watershed can alter the timing, temperature, frequency, and duration of inundation of nearby vernal pools. As described in the “Habitat or Ecosystem” section above, persistence of San Diego fairy shrimp within occupied vernal pools and complexes is dependant on maintaining suitable hydrology. Impacts outside of occupied habitat but within the watershed can alter this vital component of San Diego fairy shrimp habitat and thus threaten San Diego fairy shrimp persistence.

The complex hydrology of vernal pools is supported by both surface flows within a pool’s topographic watershed (e.g., the surface area in which water drains into a vernal pool) and subsurface flows that may extend beyond the surface watershed. Surface and subsurface lateral flows between vernal pools and the surrounding uplands influence the onset and level of inundation, and the seasonal drying of vernal pools (Hanes and Stromberg 1998). Therefore, modifications to the uplands surrounding a vernal pool (e.g., grading cuts (Bauder 1987, City of San Diego 2004a)) can negatively affect the pool’s hydrology by accelerating the flow of water into or out of the subsoil, even if such modifications occur outside the pool’s surface watershed. For example, water can be seen “leaking” out of the vernal pool complex adjacent to the western Bob Baker site along Miramar Road, where a 1 to 2 foot high cut-slope was created along the edge of a parking lot.

The listing rule discusses increases in water due to urban runoff leading to increased inundation, and pools being drained or blocked from sources of water. The listing rule does not specify the locations in which these impacts occurred, however these effects may occur when development is within or adjacent to a vernal pool watershed. Alterations of ponding could negatively affect the ability of San Diego fairy shrimp to grow and reproduce because their phenology is dependent on the onset and duration of ponding (Hathaway and Simovich 1996; Holtz 2003). Decreased inundation could result in pools not filling long enough for fairy shrimp to complete their life cycle. Conversely, increased inundation from artificial water sources (e.g., runoff from adjacent development) could cause pools to stay inundated longer than normal or even convert vernal pools into perennial pools that are not suitable for San Diego fairy shrimp.

Altered hydrology continues to threaten to this species. Since listing, through Endangered Species Act section 7 consultations and HCPs developed in conjunction with section 10 permit actions, the Service has been relatively successful at convincing developers to implement measures to reduce this threat. For example, the use of Best Management Practices reduces the amount of runoff entering vernal pool watersheds, and

restoration projects are designed to minimize water draining off impervious surfaces into vernal pool watersheds. However, even with minimization measures, Service files show that drainage and runoff issues have been observed at the J33 complex (Sweetwater High School preserve), at the Calteraces preserve in Otay Mesa, and near the JJ2 complex near Poinsettia Train Station in Carlsbad where a silt fence installed to prevent silt and debris in runoff from the Poinsettia Commons development from entering the Water's End vernal pool mitigation area failed, causing vernal pools in the mitigation area to be inundated with sediment-laden runoff (Marci Koski, Biologist, Service, pers. obs., 2008). Preserved pools should be monitored to determine if and where these impacts might be occurring, and any identified impacts need to be addressed to prevent and reverse, where feasible, further damage to hydrological systems.

Nonnative Plants

Invasion of San Diego fairy shrimp habitat by nonnative plant species was not identified as a threat to fairy shrimp habitat in the listing rule. San Diego fairy shrimp habitat has been impacted by the introduction of invasive, nonnative plants throughout the range of the species, including two nonnative wetland grasses: *Agrostis avenacea* (Pacific bentgrass) and *Polypogon monspeliensis* (annual rabbits foot grass) (Bauder 2005). Several factors contribute to the decline in habitat conditions, including native plant species being out-competed by nonnative plant species for nutrients, light, and water. Nonnative invasive plants can overtake pools and because of their water uptake decrease the number of days of inundation following rain events to the point that the pools may no longer provide suitable habitat for San Diego fairy shrimp. For example, Service files show that several vernal pools previously known from the J29-30 complex on Otay Mesa no longer pond due to dense cover of nonnative weeds; a similar situation has occurred in pools in the Ramona grasslands complex. Nonnative plants may also affect water chemistry and other aspects of pool hydrology, but more study is needed to ascertain the magnitude of these threats.

Conservation measures included in the project description or as terms and conditions of our biological opinions and incidental take statements generally include maintenance and monitoring for a period of time to ensure restoration/enhancement efforts reach certain goals. Minimizing nonnative plant species is generally one of these goals. However, long-term monitoring and maintenance of nonnative species is uncertain in most cases. Long-term management of San Diego fairy shrimp habitat may need to include measures to address nonnative vegetation control.

Agriculture

According to the listing rule, prior to listing of the San Diego fairy shrimp, vernal pools were often destroyed by agricultural activities. Agricultural activities are now limited to a few locations on Otay Mesa in San Diego County, and we no longer consider agriculture to be a significant threat to this species.

Grazing

Overgrazing in Ramona, Proctor Valley, and Otay Mesa was identified in the listing rule as a threat to San Diego fairy shrimp habitat. Limited grazing activities still occur within the range of the San Diego fairy shrimp, however grazing has been removed from much of the range of this species and where activities remain they are at low levels. Recent studies suggest that limited livestock grazing in the watershed may benefit the fairy shrimp by increasing the inundation period of the pools through reduction of vegetation (particularly nonnative grasses) in the watershed (Marty 2005) and compaction of the soil, which reduces infiltration (Gifford and Hawkins 1978). Low levels of grazing may also be used to manage nonnative plant species. Grazing may also increase the duration of pool inundation by altering soil properties and modifying the rate of evapotranspiration from plants, thus counteracting the potential decrease in precipitation brought about by climate change to some degree (Pyke and Marty 2005). Therefore, appropriate levels of grazing are no longer considered a threat to this species.

Military Activities

At the time of listing, only 3 military facilities were known to support occupied San Diego fairy shrimp habitat: Chollas Heights (U.S. Navy), and MCAS Miramar and MCB Camp Pendleton (U.S. Marine Corps). We are now aware of additional occupied habitat on Murphy Canyon Heights (U.S. Navy), and at the Naval Radar Receiving Facility in Imperial Beach (U.S. Navy) (Appendix 1). The listing rule identifies military activities, including military maneuvers and the construction of military facilities, as potential threats to vernal pools. These activities, as well as nonnative plants and other threats discussed below under “Factor E”, continue to threaten San Diego fairy shrimp and its habitat on military installations today. These threats are now ameliorated on military lands by the protections given the species under section 7 of the Endangered Species Act and by the implementation of Integrated Natural Resources Management Plans (INRMPs) that guide conservation and management of San Diego fairy shrimp habitat on military lands (see “Factor D” discussion below).

Although vernal pool sites on military lands are not considered fully protected because the military must maintain the flexibility to adapt the defense mission to political and technological developments (Department of Defense Instruction 4715.3, para. F.1.i(4)), these lands are currently managed in part for San Diego fairy shrimp pursuant to section 7 consultations and implementation of INRMPs. Below we discuss management of San Diego fairy shrimp habitat at each military facility.

MCAS Miramar supports the largest contiguous block of habitat and highest number of occupied vernal pools within the range of the San Diego fairy shrimp (39 complexes; over 1,899 pools). MCAS Miramar has an INRMP that includes measures to conserve the San Diego fairy shrimp and its habitat, and provides a benefit to this species (MCAS Miramar 2006a). Vernal pool complexes on MCAS Miramar known to contain San Diego fairy shrimp are located in Level I Management Areas and receive the highest conservation priority at the facility.

To accomplish the conservation strategies and prioritize the conservation actions described in the INRMP, MCAS Miramar has divided its lands into Management Areas. Level I Management

Areas receive the highest conservation priority; nearly all vernal pool habitat are located in Level I Management Areas. Specific management actions for vernal pools within these Level I Management Areas include: installation of protective fencing; trash removal (more than 250 tons has already been removed); nonnative plant removal; a Vernal Pool Burn Study (2000 to present); surveys to identify additional areas for habitat restoration and re-establishment; a study of the nonnative *Agrostis avenacae* occurrence in vernal pools and options for control; posting signage to delineate vernal pool areas adjacent to station activities; and ongoing vernal pool surveys, which will be used to support proactive planning and impact avoidance. These ongoing actions are expected to provide substantive conservation of San Diego fairy shrimp and its habitat on MCAS Miramar.

MCB Camp Pendleton also supports a large portion of the extant San Diego fairy shrimp habitat (9 complexes; over 279 pools). MCB Camp Pendleton completed an INRMP that includes measures to conserve the San Diego fairy shrimp and its habitat, and provides a benefit to this species. These measures involve management and control of activities that may impact occupied pools. Impacts are avoided and minimized via programmatic instructions published in the Range Training Regulations and other Base Orders. These programmatic instructions limit training and other activities in and near occupied pools. Locations of occupied pools are updated and published semiannually and are provided for all users of the Base (MCB Camp Pendleton 2007). MCB Camp Pendleton consults with the Service on construction of projects, military training activities (including off-road vehicle exercises), and infrastructure maintenance that may threaten San Diego fairy shrimp populations on Camp Pendleton. Through the section 7 consultation process and INRMP implementation, the Marine Corps has attempted to avoid and minimize impacts to pools near proposed projects, and has implemented restoration and/or additional protections to offset unavoidable impacts (RECON 2004). The Marine Corps is now in formal consultation with the Service to programmatically evaluate and address ongoing and future impacts to San Diego fairy shrimp caused by military training, fire management, facility and range maintenance, recreation, and infrastructure development activities on MCB Camp Pendleton. We expect that programmatic avoidance, minimization, and management actions specified in the forthcoming Uplands Programmatic Biological Opinion will conserve San Diego fairy shrimp on MCB Camp Pendleton.

In addition to the activities at MCB Camp Pendleton described above, the Marine Corps has initiated a study to evaluate the impact of tracked vehicle training on fairy shrimp, but results are not yet available. The military has suggested that vehicle training may promote the spread of listed fairy shrimp on MCB Camp Pendleton by compacting soils and creating depressions that hold water (ephemeral “road pools”), and that these pools may be subsequently inoculated with fairy shrimp cysts picked up and transported in mud on vehicles (U.S. Navy 2001, 2002). Although range regulations require vehicles on MCB Camp Pendleton to remain on dirt roads and avoid vernal pools (U.S. Marine Corps 2002), it is acknowledged that military vehicles leave roads occasionally during training exercises and have extensively damaged occupied fairy shrimp pools (Service 2005b). Vehicles may negatively affect fairy shrimp by disrupting pool hydrology and chemistry, crushing cysts, displacing adults or cysts to unsuitable locations, or creating conditions favorable for invasion of nonnative plants that degrade pool habitat (Service 1998a). In general, we consider vehicle use in vernal pool habitat, at MCB Camp Pendleton and elsewhere, as a substantive threat to the San Diego fairy shrimp.

The Naval Radio Receiving Facility in Imperial Beach supports 1 vernal pool complex occupied by San Diego fairy shrimp. Naval Base Coronado is implementing an INRMP completed in 2002 that includes the Naval Radio Receiving Facility and covers San Diego fairy shrimp (Naval Base Coronado 2002). Naval Base Coronado's INRMP provides conservation measures for the San Diego fairy shrimp and vernal pool habitat at the Naval Radio Receiving Facility including monitoring the status of San Diego fairy shrimp populations; posting signs around vernal pools; advising personnel to keep vehicles on the main roads while traveling through the property; and seeking opportunities to restore disturbed vernal pool habitats while considering potential impacts to the San Diego fairy shrimp. Further, the Naval Base Coronado's environmental security staff reviews projects and enforces existing regulations and orders that, through their implementation, avoid and minimize impacts to natural resources, including San Diego fairy shrimp and their habitat (Naval Base Coronado 2002).

The 2 occupied vernal pool complexes at the Murphy Canyon Navy Housing area and the 1 occupied complex at Chollas Heights Navy Housing area are not covered by INRMPs. The vernal pool complexes in these areas were restored to offset project impacts as part of section 7 consultations (Service 1995a, 2003a). While we expect the majority of the vernal pools within the complexes at the Murphy Canyon and Chollas Heights areas to be protected by the Navy, some of the pools may be impacted in the future. For example, we are currently consulting on a Child Development Center at Murphy Canyon that proposes direct and indirect impacts to approximately 1 percent of the vernal pools occupied by the San Diego fairy shrimp at that location. In addition, the Navy has informed the Service that it will not propose conservation measures (i.e., restoration) to offset impacts to vernal pools as part of the project. Recreational activities, illegal dumping, and nonnative species may also continue to impact the habitat at these sites. It is our understanding that the Navy is working to complete an INRMP that will include these 2 areas.

Conservation Measures Implemented Since Listing

Some San Diego fairy shrimp habitat was protected from development prior to listing. For example, some habitat was preserved as mitigation for project impacts through section 404 of the Federal Clean Water Act. Currently, approximately 34 of the 137 known occupied complexes (25 percent) have been at least partially conserved through section 7 consultations, HCPs, or other mechanisms of conservation (see Appendices 1 and 2). Additionally, 52 known occupied complexes (38 percent) occur on military lands subject to section 7 consultation; 49 are managed to incorporate conservation under INRMPs. These conservation mechanisms help ameliorate the effects of the threats of development and nonnative plants on this species. For example, when analyzed under section 7 or section 10 of the Act, impacts to vernal pool habitat are typically minimized through restoration of basins, including preservation, restoration, and/or enhancement of vernal pools, including transfer of vernal pool inoculum (soil containing fairy shrimp cysts) if needed. These section 7 and 10 consultations may include provisions for preservation of fairy shrimp habitat in perpetuity with appropriate fencing, management, and monitoring for preserved and restored areas to help alleviate threats and ensure the pools' long-term viability. Additionally, a viable connection with undeveloped open space and a minimum 100-foot buffer between development and vernal pool watersheds is recommended to minimize fragmentation and indirect impacts of adjacent development.

Summary of Factor A

In summary, the loss and modification of vernal pool habitat continues to be a significant threat to the San Diego fairy shrimp, especially in areas where urbanization is expected to expand. Of the estimated 137 vernal pool complexes currently occupied by San Diego fairy shrimp, Service files show that approximately 38 percent are on military land where they are managed for conservation under INRMPS or protected by other means, and approximately 25 percent are at least partially conserved on other lands. Approximately 20 percent of occupied complexes have lost some pools to development, 2 percent have been completely developed, and 18 percent are proposed for development (Appendix 1). Acquisition of land and conservation easements have resulted in the preservation of vernal pool habitat for the species, but the trend of habitat loss, fragmentation, and degradation continues, particularly on private lands. Restoration activities and associated conservation measures for San Diego fairy shrimp habitat have been implemented and improved over time. However, these measures have oftentimes been deficient or inadequately carried out. Additionally, even preserved lands are often subject to impacts such as invasion by nonnative plants, OHV use, trespassing, and other conditions that contribute to lower-quality habitat for San Diego fairy shrimp.

FACTOR B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Overutilization for commercial purposes was not known to be a factor in the 1997 final listing rule (62 FR 4925). The Service authorizes limited scientific collection through issuance of scientific/recovery permits to qualified applicants under section 10(a)(1)(A) of the Endangered Species Act; these permits contain terms and conditions to minimize mortality and injury to San Diego fairy shrimp. Overutilization for any purpose does not appear to be a threat at this time.

FACTOR C: Disease or Predation

No known diseases affect the San Diego fairy shrimp. Fairy shrimp are preyed upon by waterfowl (Krapu 1974; Swanson et al. 1974) and other native vertebrates, such as western spadefoot toad tadpoles (Branchiopod Research Group 1996). This naturally occurring predation is not considered a threat to the continued existence of the San Diego fairy shrimp. However, in vernal pools located near perennial water bodies, nonnative bullfrogs (*Rana catesbeiana*) may prey on San Diego fairy shrimp (Service 1998a). Predation by this species is not considered a substantive threat to the San Diego fairy shrimp at this time, though the level of predation is unknown and should be monitored in the future.

FACTOR D: Inadequacy of Existing Regulatory Mechanisms

At the time of listing, existing regulatory mechanisms were considered inadequate. The listing rule states, "The primary cause for the decline of this species is loss of habitat due to human activities. No State or local laws exist that adequately protect the San Diego fairy shrimp. Other regulatory mechanisms necessary for the conservation of its vernal pool habitat have also proven

inadequate and ineffective” (62 FR 4925). Current efficacy of regulatory mechanisms is discussed below.

Federal Protections

National Environmental Policy Act

The National Environmental Policy Act (NEPA) generally provides some protection for San Diego fairy shrimp. For activities undertaken, authorized, or funded by Federal agencies (i.e., projects with a Federal nexus), NEPA requires the project be analyzed for potential impacts to the human environment prior to implementation (42 U.S.C. 4371 et seq.). For instances where that analysis reveals significant environmental effects, the Federal agency must identify appropriate mitigation to offset those effects (40 CFR 1502.16). However, NEPA is a procedural statute, and while it requires disclosure and analysis of significant impacts and mitigation alternatives, it does not require that such impacts be mitigated. Actions taken by private landowners that lack a Federal nexus are not required to comply with this law.

Clean Water Act

Until recently, the U.S. Army Corps of Engineers (Corps) regularly took jurisdiction over vernal pools. At the time of listing, the Corps Los Angeles District (Corps LAD) generally took jurisdiction over all San Diego fairy shrimp habitat, regardless of whether it consisted of road pools (ephemeral pools inhabited by San Diego fairy shrimp or other vernal pool fauna, formed inadvertently by human activities such as vehicle use) or other unvegetated pools that were found within historical vernal pool habitat. However, recent Supreme Court rulings have called into question the Corps’ regulation of vernal pools based on the definition of “waters of the United States” in the Clean Water Act: Solid Waste Agency of Northern Cook County v. U.S. Army Corps of Engineers (531 U.S. 159) (2001) (*SWANCC*) and Rapanos v. United States, 126 S. Ct 2208, U.S. (2006)). In these cases, the Court adopted a more restrictive view of “waters of the United States”. Following these rulings, Corps regulatory oversight of vernal pools is in doubt because of their “isolated” nature, and the Corps has made determinations regarding regulation of such wetland areas (including vernal pools) on a case-by-case basis. In response to the Supreme Court decisions, the Corps and the U.S. Environmental Protection Agency (USEPA) have recently released a memorandum providing guidelines for determining jurisdiction under the CWA. Recent Corps guidance indicates that wetlands adjacent to navigable-in-fact waters of the U.S. are subject to regulation under the Clean Water Act, as are non-adjacent wetlands that are shown to have a significant nexus to navigable waters. The guidelines provide for a case-by-case determination of a “significant nexus” standard that may protect some, but not all, vernal pool habitat (USEPA and Corps 2007). The overall effect of the new permit guidelines on loss of vernal pool habitat is not known at this time. In the face of these Supreme Court decisions, the Corps LAD has not regulated road pools or other pools that lack vernal pool indicator plants, regardless of whether they contain San Diego fairy shrimp or other vernal pool fauna. In light of these rulings and changes in practice since listing of the San Diego fairy shrimp, the Corps LAD’s continued regulation of wetlands that contain San Diego fairy shrimp habitat is, at best, uncertain. Should Corps regulation of wetlands that contain San Diego fairy shrimp habitat be discontinued, unmitigated destruction of San Diego fairy shrimp habitat is likely to occur.

Endangered Species Act

The Endangered Species Act of 1973, as amended (Act), is the primary Federal law that provides protection for San Diego fairy shrimp. Section 7(a)(2) requires Federal agencies to consult with the Service to ensure any project they fund, authorize, or carry out does not jeopardize a listed species. Since its listing, the Service has analyzed the potential effects of many projects on the San Diego fairy shrimp in section 7 consultations under section 7(a)(2) of the Act.

A jeopardy determination is made for a project that is reasonably expected (either directly or indirectly) to appreciably reduce the likelihood of both the survival and recovery of a listed species in the wild. Section 9 of the Act prohibits the “take” of federally endangered wildlife. If the Service concludes that a proposed action is not likely to result in jeopardy to a listed species, but will result in incidental take of the species, it must include with its biological opinion an incidental take statement that specifies the amount or extent of take likely to result from the proposed action, and provides reasonable and prudent measures, and terms and conditions to implement those measures, to minimize the effects of such take on the species. Such reasonable and prudent measures and implementing terms and conditions may only require minor changes to the proposed project. Under the terms of section 7(b)(4) and section 7(o)(2) of the Act, taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of an incidental take statement. The Service works with Federal, State, and local agencies, and with private project proponents, to minimize project effects to listed vernal pool species, and to compensate for the loss of habitat by preservation, restoration, and/or enhancement of vernal pool habitat, through section 7 consultations.

Since its listing, the Service’s Carlsbad Fish and Wildlife Office has issued 48 biological opinions that address San Diego fairy shrimp under section 7 of the Act. Impacts to approximately 10.8 acres of San Diego fairy shrimp habitat, and other impacts not quantifiable in terms of acreages, have occurred from projects covered by these consultations. Typically, the projects have incorporated both avoidance and minimization of impacts, such as by preservation, restoration, and enhancement measures, to reduce or offset impact to the species and its habitat. In addition, the impacts of take of San Diego fairy shrimp have been minimized through reasonable and prudent measures incorporated into the incidental take statement accompanying the biological opinions.

Incidental take permits, pursuant to section 10(a)(1)(B) of the Act, may be issued to authorize take of listed animal species resulting from projects without a Federal nexus. Section 10 provides protection for San Diego fairy shrimp through the implementation of Service-approved habitat conservation plans (HCP) that detail measures to minimize and mitigate the potential impacts of take resulting from a project to the maximum extent practicable. The San Diego fairy shrimp is a “covered species” under most existing and planned regional HCPs in southern California, including those in San Diego and Orange counties, which cover most of the species’ current range. As a covered species in these HCPs, the San Diego fairy shrimp would be afforded an additional layer of regulatory protection, even if it were to be delisted. The two most significant regional HCPs for the San Diego fairy shrimp are the Orange County Southern Subregion Habitat Conservation Plan (Southern Subregion HCP) (approved by the Service in

2007), and the San Diego County Multiple Species Conservation Program (MSCP)/Natural Communities Conservation Plan/Habitat Conservation Plan (MSCP/NCCP/HCP) (approved by the Service in 1997).

Orange County Southern Subregion HCP

The Southern Subregion HCP was developed in support of applications by the County of Orange, Rancho Mission Viejo, and the Santa Margarita Water District for incidental take permits for 7 federally listed species, including the San Diego fairy shrimp, and 25 unlisted plants and animals, in connection with proposed residential and commercial development and related actions in southern Orange County. We issued incidental take permits based on the plan on January 10, 2007.

The plan area encompasses 86,076 acres (Service 2007b) of land in southern Orange County and, over its 75-year permit term, will establish an approximately 32,818-acre Habitat Reserve. The Habitat Reserve will consist of 11,950 acres of County-owned lands within the O'Neill Regional Park, Riley Wilderness Park, and Caspers Wilderness Park, and approximately 20,868 acres of land owned by Rancho Mission Viejo.

Two complexes occupied by San Diego fairy shrimp, Chiquita Ridge and Radio Tower Road, occur in Orange County are covered by the Southern Subregional HCP. All vernal pools supporting San Diego fairy shrimp and their contributing hydrological resources on Chiquita Ridge and on Radio Tower Road will be permanently conserved and adaptively managed in the Habitat Reserve. The Chiquita Ridge complex has already been fenced and conserved within the existing Ladera Open Space. The adaptive management program for San Diego fairy shrimp will focus on maintaining the existing vernal pools and San Diego fairy shrimp in the Habitat Reserve by maintaining water quality/quantity, controlling nonnative invasive species, managing livestock grazing, and minimizing human access and disturbance (Dudek and Associates 2006c).

Regular monitoring of the Chiquita Ridge and Radio Tower Road vernal pools will track the status of the San Diego fairy shrimp, water quality conditions, and need for specific management actions. Annual monitoring will occur every year for the first 5 years following initiation of monitoring once occupied areas are dedicated to the Habitat Reserve and every 3 years thereafter (Dudek and Associates 2006c). Monitoring was initiated in the Chiquita Ridge pools in 2007; however, monitoring of the Radio Tower Road pools is not expected until phased development of Planning Area 5 and its associated dedication of conserved lands to the Habitat Reserve occurs in approximately 2018 (Dudek and Associates 2006c).

City of San Diego and County of San Diego Subarea plans under the San Diego County MSCP

In southwestern San Diego County, the MSCP planning area encompasses more than 582,000 acres and includes the County of San Diego, City of San Diego, 10 other city jurisdictions, and several independent special districts. Under the broad umbrella of the

MSCP, each participating jurisdiction prepares a subarea plan that implements the goals of the MSCP within that jurisdiction. The MSCP provides for the assembly and establishment of approximately 171,000 acres of preserve areas to provide conservation benefits for 85 federally listed and sensitive species, including the San Diego fairy shrimp, over the permit term. The MSCP anticipates the conservation of at least 88 percent of vernal pool habitat, requires avoidance of impacts to the San Diego fairy shrimp and its habitat to the maximum extent practicable, mitigation for impacts deemed unavoidable, and management to protect habitat against edge effects to San Diego fairy shrimp.

Approximately 55 occupied vernal pool complexes are covered by the City of San Diego's subarea plan. The City's subarea plan does not lay out specific, quantified goals for San Diego fairy shrimp conservation (e.g., acres of habitat to be conserved, amount of habitat loss allowed); however, consistent with the Regional MSCP plan, the City's subarea plan anticipated that at least 88 percent of all vernal pool habitat will be conserved and managed in accordance with the area-specific management directives outlined in the subarea plan, and as guided by the City's Vernal Pool Management Plan (the Vernal Pool Management Plan completed in 1996 will be replaced by the draft Vernal Pool Management Plan (City of San Diego 2006) upon adoption of the current draft by the City Council). As of 2006, the City reported that approximately 54 percent, or 1,369 pools, of all currently identified vernal pool habitat within the boundaries of the City's subarea plan were conserved by covenant of easement, conservation easement, or dedication in fee title to the City (City of San Diego 2006). This includes about 27 of the known occupied complexes according to Service files (49 percent)). Habitat managers have been identified, management plans have been put in place, and/or management activities (e.g., restoration, maintenance, monitoring) have been carried out at many conserved sites. However, according to Service files many conserved sites lack long-term management and most sites are in need of additional management to address threats. The City received funds from a 2007 Transnet grant to carry out restoration activities at conserved vernal pool sites. However, these restored sites still need long-term management to maintain the conservation benefit. The City's draft Vernal Pool Management Plan details additional management needed to address ongoing or potential impacts in conserved areas (City of San Diego 2006). The City has identified additional funding sources to carry out long-term management at conserved sites and is working with several landowners to place additional sites into conservation. The Service continues to work closely with the City to finalize and implement the Vernal Pool Management Plan and recent restoration activities demonstrate the City's commitment to conserve the San Diego fairy shrimp.

The City's section 10(a)(1)(B) permit limits incidental take authorization for this species to areas outside of jurisdictional waters of the United States, as that term was understood prior to the "SWANCC" decision. As discussed above under "Clean Water Act," prior to SWANCC and at the time the City's incidental take permit was issued, the Corps LAD generally took jurisdiction over all San Diego fairy shrimp habitat, including road pools or other unvegetated pools that were found within historical vernal pool habitat. Therefore, the Service anticipated individualized review of projects impacting San Diego

fairy shrimp habitat under section 404 of the Clean Water Act and section 7 of the Act to insure compliance with the Environmental Protection Agency's Clean Water Act 404(b)(1) guidelines and the Federal policy of "no net loss of wetland function and values." However, the SWANCC decision has rendered future Clean Water Act jurisdiction over vernal pools uncertain. Additionally, a 2006 Federal district court ruling in Center for Biological Diversity v. Bartel, 98-CV-2234 (S.D.Cal.) enjoined the incidental take permit issued to the City of San Diego as applied to the San Diego fairy shrimp and six other vernal pool species. The court held that the City's subarea plan does not provide adequate protection for the San Diego fairy shrimp in light of SWANCC and as a result of other plan deficiencies. The injunction remains in place and the decision is currently on appeal. Meanwhile, any incidental take of San Diego fairy shrimp within the City of San Diego may only be authorized through a separate section 7 consultation, independent of the MSCP and subarea plan, where a Federal nexus exists, or through individual HCPs approved by the Service pursuant to section 10 of the Act. Because the subarea plan is also an approved Natural Communities Conservation Plan (NCCP) under the State of California's Natural Communities Conservation Planning Act (NCCPA), and the NCCP has not been challenged, the City's obligations under the NCCP to avoid impacts to vernal pool species, including the San Diego fairy shrimp, to the maximum extent practicable, and to monitor and manage vernal pools, remains in place notwithstanding the Federal injunction.

Like the City's subarea plan, the County's subarea plan does not set clear goals for San Diego fairy shrimp conservation. According to Service files, about 7 occupied complexes are covered by the County of San Diego's subarea plan; 2 have been conserved and development has been proposed on at least 2 others. Management goals set forth in the Regional plan have not yet been realized on the conserved lands in the County subarea.

The Sikes Act

The Sikes Act (16 U.S.C. 670) authorizes the Secretary of Defense to develop cooperative plans for conservation and rehabilitation programs, and to establish outdoor recreation facilities on military installations. The Sikes Act also provides for the Secretaries of Agriculture and the Interior to develop cooperative plans for conservation and rehabilitation programs on public lands under their jurisdiction. While the Sikes Act of 1960 was in effect at the time of the San Diego fairy shrimp listing, it was not until 1997 when the Sikes Act Improvement Act was enacted that Department of Defense (DOD) installations were required to prepare Integrated Natural Resource Management Plans (INRMPs). An INRMP provides for the management of natural resources on military lands consistent with the use of military installations to ensure the readiness of the Armed Forces. Management under an INRMP may include surveying, monitoring, and restoration of natural resources. Implementation of INRMPs is subject to funding availability and does not preserve any military lands in perpetuity, as ultimately those lands may be necessary for National Security. Several INRMPs have been adopted since the listing of the San Diego fairy shrimp. The most significant for the San Diego fairy shrimp are the INRMPs for MCAS Miramar and MCB Camp Pendleton.

On MCAS Miramar, which encompasses much of the extant habitat occupied and suitable for the San Diego fairy shrimp, vernal pool conservation and management is guided by an INRMP that was initially developed in 2000 and updated in 2006 (MCAS Miramar 2006a). The MCAS Miramar's strategy for conservation and management of San Diego fairy shrimp is to limit activities, minimize development, and mitigate actions in areas supporting high densities of vernal pool habitat.

The Marine Corps adopted an INRMP for MCB Camp Pendleton in 2001 (MCB Camp Pendleton 2001), which was further revised in 2007 (MCB Camp Pendleton 2007). The MCB Camp Pendleton INRMP includes measures to conserve the San Diego fairy shrimp and its habitat, and to provide a benefit to the species. These measures involve management and control of activities that may impact occupied pools. Like other INRMPs, it is largely ecosystem-based except where biological opinions under section 7 of the Act direct species-specific actions. The Service and the Marine Corps are currently consulting under section 7 of the Act on the Marine Corps' plan to programmatically avoid and minimize the effects of the Marine Corps' activities on federally listed upland and wetland species, including San Diego fairy shrimp on MCB Camp Pendleton. Conservation measures resulting from this section 7 consultation are expected to be incorporated into future revisions of the INRMP and are expected to provide specific direction to guide San Diego fairy shrimp management and conservation. Pending completion of this consultation, the Marine Corps has incorporated interim San Diego fairy shrimp management and conservation measures within MCB Camp Pendleton's INRMP (MCB Camp Pendleton 2007).

Further information on the MCAS Miramar and MCB Camp Pendleton INRMPs is included in the "Military Activities" discussion under the "Factor A" section above.

State Protections

California Endangered Species Act

Although the San Diego fairy shrimp is not listed under the California Endangered Species Act of 1984 (CESA), it can co-occur with other listed state species and therefore may receive indirect protection under CESA. CESA generally requires an incidental take permit for activities that would result in take of a State-listed species. Among other requirements for a State incidental take permit, a project proponent must demonstrate that any such take will be fully mitigated

California Environmental Quality Act

The California Environmental Quality Act (CEQA) requires disclosure of the significant effects of a proposed action and generally requires that such significant effects be mitigated to a level of insignificance. Section 15065 of the CEQA Guidelines requires a mandatory finding of significance if a project may substantially reduce the numbers or restrict the range of an endangered, rare, or threatened species. "Threatened, rare, or endangered" species includes species listed as threatened or endangered under the ESA (CEQA Guideline section 15380). The CEQA (chapter 2, section 21050 *et seq.* of the California Public Resources Code) requires government agencies to consider and disclose environmental impacts of projects and to avoid or

mitigate them where possible. Under CEQA, public agencies must prepare environmental documents to disclose environmental impacts of a project and to identify conservation measures and project alternatives. Through this process, the public can review proposed project plans and influence the process through public comment. If significant effects are identified, the lead agency may require mitigation, require changes to a project, or decide that mitigation is unfeasible due to overriding considerations. Thus, while the San Diego fairy shrimp may be afforded some protection under CEQA, this protection is not guaranteed and is ultimately dependent upon the discretion of the lead agency.

California Porter-Cologne Act

The primary law regulating water quality in California is the California Porter-Cologne Act of 1969 (section 13000 *et seq.*, California Water Code). This Act designates authority over surface water and groundwater quality to the State Water Resources Control Board and the nine Regional Water Quality Control Boards. Additionally, this Act regulates the discharge of fill into waters of the state (section 13260 *et seq.*, California Water Code). “Waters of the state” is defined as “any surface water or groundwater, including saline waters, within the boundaries of the state,” and includes vernal pools (California Regional Water Quality Control Board San Diego Region 2001). While this Act affords some protection to San Diego fairy shrimp habitat, automatic waivers of discharge requirements are granted if the Regional Boards do not respond to applications within 120 days. For example, this waiver occurred for the proposed Ramona Unified School District project (Service 2007a), which proposes activities with impacts to San Diego fairy shrimp habitat.

Natural Communities Conservation Planning Act

In 1991, the State of California passed the Natural Communities Conservation Planning Act (NCCP) Act to address the conservation needs of natural ecosystems throughout the State. The initial focus of this program was the coastal sage scrub community in southern California, although other associated vegetation communities are also being addressed in this ecosystem-based planning approach. The San Diego fairy shrimp has been treated as a covered species and thus provided some level of protection under several regional NCCPs. The most significant NCCP plan to the San Diego fairy shrimp is the City of San Diego MSCP, which is discussed above.

Local Laws and Regulations

The City of San Diego has enacted a local ordinance for wetland resources, including vernal pools that may be inhabited by San Diego fairy shrimp, which requires avoidance of vernal pools to the maximum extent practicable. The ordinance does not cover road pools or other unvegetated, disturbed pools. Additionally, the City ordinance has not recognized many threats associated with development (e.g., habitat isolation and fragmentation, indirect effects of adjacent development, alternation of hydrology). The City of San Diego continues to approve projects that completely surround vernal pools with development and directly impact road pools occupied by the San Diego fairy shrimp. Therefore, local regulations do not adequately protect the San Diego fairy shrimp and its habitat.

United Mexican States Law

The Service is not aware of any existing regulatory mechanisms that would protect the San Diego fairy shrimp or its habitat where it occurs in northwestern Baja California, Mexico.

Summary of Factor D

In summary, the Federal Endangered Species Act provides the greatest regulatory protection to the San Diego fairy shrimp. The additional potential protection provided by other Federal, State, and local laws and ordinances is discretionary, incomplete, subject to funding availability and changing missions, and/or largely dependant on the federally listed status of the San Diego fairy shrimp. As a result, other Federal, State, and local laws and ordinances do not independently or collectively provide adequate regulatory protection to the San Diego fairy shrimp.

FACTOR E: Other Natural or Manmade Factors Affecting Its Continued Existence

Indirect Effects of Development/Habitat Fragmentation

In addition to the direct effects of development on San Diego fairy shrimp habitat discussed above under Factor A, development can also impact the species indirectly (i.e., via impacts brought on over time as a result of adjacent development). The final listing rule identified secondary (i.e., indirect) impacts associated with urbanization that included disposal of waste materials and trash in pools; runoff containing pesticides, detergents, fertilizer, and motor oil; and dust and other forms of air or water pollution from surrounding commercial or agricultural development. These effects continue to threaten the species today. Additionally, we now recognize that increased development and fragmentation of habitat may impact population dynamics of the species as discussed below.

Alteration of Population Dynamics

Population genetics effects related to habitat fragmentation were not addressed in the final listing rule. On a regional scale, San Diego fairy shrimp habitat is naturally fragmented (Bohonak 2005). How and to what degree dispersal of San Diego fairy shrimp occurs is unknown at this time. Since listing, genetic analyses of San Diego fairy shrimp have shown a high level of genetic (mitochondrial DNA) divergence among vernal pool complexes, which implies that little genetic mixing occurs among complexes naturally (Bohonak 2005). Habitat fragmentation within complexes or groups of nearby complexes may also disrupt hydrological systems and the low levels of gene flow that appear to be needed to maintain the natural, overall genetic diversity of the species. The mixing that does occur could happen via a combination of any of a number of potential mechanisms, including infrequent large-scale flooding events, dispersal of cysts by animals (e.g., waterfowl), and wind dispersal of cysts in desiccated soils. It is presumed that extirpated populations of San Diego fairy shrimp could be re-established through these natural dispersal mechanisms in the absence of habitat fragmentation. Due to the lack of information regarding dispersal of San Diego fairy shrimp over larger distances, it is not possible to predict what effects fragmentation of habitat on a regional scale will have on the genetic make-up and

population dynamics of the species. More research on this subject is needed to assess the significance of this threat.

Humans and their pets may increase genetic homogenization between pool complexes by transporting cysts from one pool or complex to another on tires, shoes (including the shoes of biologists conducting surveys or restoration work), pet fur, etc. Preliminary results of a genetic study on the species indicate there is more gene flow between pool complexes in areas that are adjacent to urbanization, suggesting that development and human encroachment may result in mixing genetically distinct populations and thereby reduce the overall natural, genetic diversity of the species (Bohonak 2005; see “Genetics” discussion above).

Human Access and Disturbance

Impacts due to human access in San Diego fairy shrimp habitat were identified as threats to the species in the final listing rule. The potential for human access and disturbance in fairy shrimp habitat increases as greater numbers of people are brought in close proximity of the habitat via encroaching development. Human encroachment into San Diego fairy shrimp habitat on foot or on motorized or non-motorized vehicles affects the species by crushing San Diego fairy shrimp cysts. Hathaway et al. (1996) demonstrated San Diego fairy shrimp cysts can be crushed under minimal weight (less than 1 newton (less than 100 grams of force) when dry; less than 0.07 newton when wet), and that some cysts are more resilient to crushing than others, depending on shape. The study measured the force necessary to crush cysts between two microscope slides, but in vernal pools the force applied to cysts by hiker’s feet, OHV tires, etc., is at least partially diminished by the “cushioning” of soil surrounding the cysts allowing many cysts to withstand these impacts. In a study more comparable to field conditions, Eriksen et al. (1986) looked at the affects of OHV use on crustacean species on a desert playa, and found that simulated OHV traffic resulted in significantly increased breakage of cysts of the alkali fairy shrimp (*Branchinecta mackini*), a common species present in southern California, but did not break all cysts exposed to the impact. Hathaway et al. (1996) also looked at the strength of *Branchinecta mackini* cysts and found them to be more resilient than San Diego fairy shrimp cysts. The fact that fairy shrimp cysts are susceptible to crushing, as reported by Eriksen et al. (1986), though not necessarily under the low forces predicted by Hathaway et al. (1996), coupled with the fact that San Diego fairy shrimp are found in vernal pool complexes that have been impacted by vehicle use and trampling (for examples, see City of San Diego 2004a, City of San Diego 2006), indicates that some cysts in a pool are likely destroyed by these impacts. It is unknown if cysts that are not crushed remain viable following these types of impacts (e.g., if viability of uncrushed cysts is adversely affected by shell damage or soil compaction). If not abated these cyst-crushing impacts may accumulate over time, leading to a decline of cysts below a number necessary to support a viable population.

In addition to crushing fairy shrimp cysts, this type of off-road activity (including motorcycles and bicycles) can generally degrade San Diego fairy shrimp habitat, altering pool shape and compacting soil, potentially impacting pool hydrology. The Department of Defense is undertaking a study on the effects of OHV use on San Diego fairy shrimp habitat at MCB Camp Pendleton, which should provide further insight into the nature of OHV impacts on the species and its habitat.

At the time of listing, OHV use was a threat to the San Diego fairy shrimp (62 FR 4925). In the listing rule, OHV use was described as ongoing in Proctor Valley, Kearny Mesa, Otay Mesa, and Poway. Service files show that threats from recreational OHV use have increased since listing and continue to pose a substantive threat to the San Diego fairy shrimp. This threat is especially pervasive in Otay Mesa, Marron Valley, and Proctor Valley due to OHV use associated with Border Patrol activities (City of San Diego 2006), which have created many unauthorized roads often used and expanded by recreational OHV users, and at MCB Camp Pendleton due to military training. Fencing, signage, and maintenance of fencing are needed to help protect San Diego fairy shrimp and its habitat from recreational OHV users.

To a lesser degree, OHV use for emergency response (e.g., fire suppression and aviation emergencies) and law enforcement actions may impact San Diego fairy shrimp and its habitat in various locations while providing vital services (Bauder 1986a, 1986b, 1987). Many vernal pools occur within or adjacent to large open-space areas that are prone to fire during drought, such as the vernal pools at Otay Lakes that burned in the 2003 Otay Fire. Fire suppression activities in some locations may impact vernal pools and San Diego fairy shrimp due to vehicle and people/equipment movement through pools or creation of firebreaks. Additionally, vernal pools occur near both the Brown Field, Montgomery Field, and MCAS Miramar airports where aviation emergency response may occur.

Service files show that almost all remaining San Diego fairy shrimp habitat is potentially threatened to some degree by increasing human access and disturbance. To lessen this impact, the Service typically recommends a 100-foot habitat buffer and fencing between new development and the watershed boundary of preserved or restored vernal pools, although this is not always implemented. At some sites, human access and disturbance are limited by fencing. For example, the secure nature of some sites (e.g., Montgomery Field and Brown Field, both secure airport sites) minimizes human trespass. On MCAS Miramar, human access and disturbance to vernal pools are minimal in most areas because Miramar is a secure site and most vernal pool complexes on Miramar are in secluded areas. On MCB Camp Pendleton, personnel are instructed to avoid driving OHVs through vernal pools during military maneuvers (foot traffic through pools, however, is allowed (MCB Camp Pendleton 2007)).

Several preserved and most unpreserved vernal pool complexes are not fenced and are thus subject to illegal activities, although “No Trespassing” signs may be posted in some cases. The City of San Diego’s draft Vernal Pool Management Plan (2006) reports observed or potential effects of human encroachment for almost all complexes listed within the document. Fencing around vernal pools is sometimes damaged or removed by trespassers to gain illegal entry. For example, vandals removed the protective fencing surrounding vernal pool complexes and constructed moguls (bumps probably used for jumping bicycles) within the vernal pool watersheds located in the West Otay Mesa Environmental Preserve (The Environmental Trust 2003). Trash, illegally planted nonnative species, and dirt discarded by an adjacent landowner were documented at the Carroll Canyon Vernal Pool Preserve (City of San Diego 2004b). Trash has also been observed at a complex in Kearny Mesa surrounded by industrial/commercial development and Mira Mesa Boulevard (City of San Diego 2004a), and numerous other complexes in the City of San Diego (City of San Diego 2006). Service files contain additional

observations of effects of human encroachment that include dumping in San Marcos, dumping and OHV use in the Del Mar Mesa National Wildlife Refuge, and numerous disturbances to the Fairview complex in Orange County³. Maintenance and management of preserved habitat in perpetuity can ameliorate these threats (e.g., by maintaining fences and signage, removing trash). However, the level of management necessary to reduce this threat has not been implemented for all preserved complexes.

Pesticides and Other Pollutants

Pesticide use was identified in the listing rule as a threat to San Diego fairy shrimp in the Fairview complex in Orange County (insecticide use) and generally (herbicide use). San Diego fairy shrimp may be exposed to pesticides used to control weeds and insects. Herbicides are commonly used to control weeds outside of vernal pools (e.g., along roads, farms, and residential landscaping) and within vernal pools themselves (e.g., for enhancement/restoration projects). One study showed that the commonly used herbicide Roundup[®] may pose a risk to San Diego fairy shrimp (Ripley et al. 2002). Additionally, pesticide applications for mosquito larvae control have become increasingly common to combat West Nile Virus. Although at this time the degree of this threat to San Diego fairy shrimp is unknown, the fact that some pesticides are designed specifically for the purpose of killing certain invertebrates adds strength to the argument that they may be a substantive threat to San Diego fairy shrimp in areas where they are used. This potential threat should be monitored and measures should be developed to help prevent the spread of pesticides into San Diego fairy shrimp habitat. The Service is currently undertaking research to determine the effects of some pesticides on the species.

Runoff may also introduce pollutants that could be toxic to the species, or alter aspects of water chemistry such as pH, alkalinity, and salinity, to which the species has been shown to be sensitive (Gonzalez et al. 1996). Airborne pollutants can be introduced via rainfall and runoff as well.

Dumped trash and other litter may decrease water quality as materials dissolve or decompose. Dumped material can also fill pools leaving little or no space for water to collect, or cover the bottom of pools, preventing larvae hatching from cysts from moving from the soil into the water column.

Clear, conclusive data quantifying the effects of the indirect impacts of development discussed above on San Diego fairy shrimp are lacking. We do not know how such effects may alter the demographics, genetic makeup, or robustness of San Diego fairy shrimp populations. We do not currently have a means of quantifying the abundance of San Diego fairy shrimp within a pool or complex; we can only determine presence or absence of the species. Thus, we are not able to detect declines in abundance until the point of extirpation. Given the documented sensitivity of the species to the chemical and physical attributes of its habitat, it is likely that these threats, especially in combination with one another, are having some detrimental impact on San Diego fairy shrimp. More study is needed to accurately assess the magnitude and extent of the threat to San Diego fairy shrimp from the indirect impacts of development. However, as more land is

³ Surveys in the Fairview Park complex in 2004 did not detect San Diego fairy shrimp in pools previously occupied by the species (Simovich 2005b). The species may have been present, but at such low numbers it was not detected.

developed and the amount of intervening space in between development and habitat decreases, these effects will increase (see the “Development” section of the “Factor A” analysis for discussion of human population growth rates in San Diego and Orange counties). Based on the fragmented nature of known occupied habitat remaining and the proximity of all remaining occupied habitat to development; effects of human access and other disturbances related to development increasingly threaten San Diego fairy shrimp throughout its extant range.

Competition and Hybridization with the Versatile Fairy Shrimp (*Branchinecta lindahli*)

The versatile fairy shrimp (*Branchinecta lindahli*) is common throughout western North America and is found in a wide variety of habitats from roadside ditches to playas and prairie potholes, and tend to inhabit disturbed sites (Gonzalez et al. 1996). The versatile fairy shrimp has been documented in only a few locations within the range of the San Diego fairy shrimp in relatively disturbed pools at Otay Mesa, MCAS Miramar, Del Mar Mesa, and MCB Camp Pendleton. The two species are known to hybridize in the laboratory (Fugate 1998) and in the field (see Appendix C in MCB Camp Pendleton 2005). The continual disturbance of vernal pool habitat by OHVs used for military training may increase the distribution of the versatile fairy shrimp on MCB Camp Pendleton. Additionally, the versatile fairy shrimp was recently found in one pool within the Torrey Highlands vernal pool restoration site, possibly introduced by restoration crews from another site (Scott McMillan, EDAW, pers. comm. 2007). Although the known distribution of this species is still fairly limited within the range of the San Diego fairy shrimp, hybridization and competition could threaten the San Diego fairy shrimp in the future should the range of the versatile fairy shrimp expand. This potential threat should be monitored and measures developed to help prevent the spread of the versatile fairy shrimp into San Diego fairy shrimp habitat.

Drought and Climate Change

Drought was noted in the listing rule as a stochastic (random or unpredictable) event that could have drastic effects on the species given its fragmented and restricted range (62 FR 4925). Drought is likely to decrease or terminate reproductive output as pools fail to flood, or dry up before reproduction is complete. Based on existing data (Helm 1998; see also Eriksen and Belk 1999), weather conditions in which vernal pool flooding promotes hatching, but in which pools dry (or become too warm) before embryos are fully developed, are expected to have the greatest negative effect on fairy shrimp resistance and resilience. Long-term or continuing drought conditions may deplete cyst banks in affected pools as new cysts are not deposited and depletion of cyst banks occurs. Because current monitoring protocols typically require only one survey for crustaceans each monitoring year, they cannot determine the frequency with which the shrimp die off before completing reproduction (ECORP 2006). Though the species is adapted to some degree of unpredictability in its habitat (Eriksen and Belk 1999), it is unknown how the species would respond to exacerbation of drought conditions potentially brought on by climate change, and the combination of drought with other threats discussed in this review.

Climate change was not discussed in the listing rule, but is now considered a potential threat to San Diego fairy shrimp. Climate change has the potential to adversely affect the fairy shrimp through changes in vernal pool inundation patterns and consistency. Climate scientists are able

to predict, with a high level of certainty, that California's climate will become warmer within the 21st century (Cayan et al. 2005; Field et al. 1999), although there is still uncertainty about regional effects of warming. Current climate change predictions for terrestrial areas in the Northern Hemisphere indicate warmer air temperatures, more intense precipitation events, and increased summer continental drying (Field et al. 1999; Cayan et al. 2005; IPCC 2007). However, predictions of climatic conditions for smaller sub-regions such as California remain uncertain. Potential responses of California ecosystems to climate change fall into three response categories: geographical responses, changes in the way ecological processes work, and changes in the kinds of plants and animals that comprise the communities (Field et al. 1999).

Geographical responses include latitudinal and elevational shifts in species ranges. Scientists expect climate warming to cause shifts in the distribution and abundance of many species (McLaughlin et al. 2002). The ability of fairy shrimp to survive is likely to depend in part on their ability to disperse to pools where conditions are suitable (Bohonak and Jenkins 2003; Bonte et al. 2004). Loss and fragmentation of vernal pool habitat is thought to decrease dispersal ability. Therefore, any range shift prompted by climate change may be more difficult due to factors such as the loss of potential habitat from development, occupation of potential habitat by nonnative species, and lack of appropriate soil substrates (Field et al. 1999). Remnant suitable habitats, even within conservation banks, may be too far apart to allow dispersal or natural recolonization after a disturbance (Field et al. 1999). Existing preserves in California may not provide the full range of conditions needed to sustain fairy shrimp during variable climatic conditions (Pyke 2004, 2005b).

The likely impacts of climate change on ecological processes are closely connected to availability of water. Vernal pools are particularly sensitive to slight increases in evaporation or reductions in rainfall due to their shallowness and seasonality (Field et al. 1999). California winters may become warmer and wetter, while El Niño frequency and intensity may increase. Even modest changes in climate could result in more runoff in winter with less runoff in spring and summer, more winter flooding, and drier summer soils, thereby altering the seasonality and duration of vernal pool hydration (Cayan et al. 2005; Field et al. 1999). Fairy shrimp crustaceans have developed life-history strategies to survive drought periods. They are, however, adapted to complete their life cycles within limited temperature ranges and require a minimum length of inundation to reach maturity and reproduce. Although fairy shrimp mature relatively fast, they are able to produce more eggs when water conditions are suitable for a longer period of time (see Eriksen and Belk 1999; Helm 1998). Climate change is expected to lead to increased variability in precipitation (McLaughlin et al. 2002), and to increased loss of soil moisture due to evaporation and transpiration of water from plants (Field et al. 1999), which may exacerbate effects due to drought. Drought-mediated decreases in water depth and inundation period could increase the frequency at which pools dry before shrimp have completed their life cycle, or cause pool temperatures to exceed more often temperatures suitable for hatching and persistence of the species.

The species present in California's vernal pools are expected to change over time. Presence of fairy shrimp appears to be associated with precipitation patterns and other climate factors, including aridity (Eriksen and Belk 1999; Jones and Stokes 2006). Although the specific effects of climate change on fairy shrimp are unknown, the effect of shifting temperatures on winter

storm events and pool conditions have the potential to adversely affect the San Diego fairy shrimp. This species may disappear from some areas to be replaced by species that are more tolerant. Climate change may also result in the alteration of vernal pool habitats through changes to nitrogen deposits or increased carbon dioxide (Pyke 2005a), thereby affecting water chemistry of pools and suitability of pools for specific species. Inter-annual population fluctuations could be amplified by changes in precipitation and could lead to rapid extinctions of individual populations, even where populations are already known to fluctuate widely (McLaughlin et al. 2002). It is also possible that fairy shrimp species could be buffered from extinction due to the presence of cyst banks, although the extent of this protection is unknown (Bohonak and Jenkins 2003), and cyst banks also could be depleted after successive years of prolonged drought.

At this time, the degree to which climate change threatens San Diego fairy shrimp is unknown. While we recognize that climate change is an important issue with potential effects to listed species and their habitats, we lack adequate information to make accurate predictions regarding its effects to particular species and habitats.

Fire

The listing rule did not specifically identify fire as a threat to San Diego fairy shrimp. Though there is not much information available detailing the actual effects of fire on San Diego fairy shrimp, the information that does exist indicates that San Diego fairy shrimp cysts are not significantly impacted by fire. A study carried out by Wells et al. (1997) found that dry San Diego fairy shrimp cysts from pools subjected to fire produced viable hatched fairy shrimp at frequencies comparable to cysts from unburned pools. Additionally, a study done by the U.S. Marine Corps looking at the effects of fire on vernal pools on MCAS Miramar found no apparent negative effects on fairy shrimp in the 3 years following a 2000 wildfire (MCAS Miramar 2005). Wells et al. (1997) speculated that cysts were not impacted by fire in their study due to the cysts' innate resistance to heat, the insulation against heat provided by the soil, and the fact that the soil is only heated briefly and at low intensity by fire because of the relatively light fuel load usually present in fairy shrimp habitat. Although very dense vegetative material found in some San Diego fairy shrimp habitat may result in more intense fires that could have deleterious effects on cyst viability (Wells et al. 1997).

There is also very little information available regarding impacts of fire on hatched fairy shrimp in water-filled pools. After hatching, San Diego fairy shrimp may be impacted by fire via increased water temperatures which could kill or otherwise harm individuals; however, heat is unlikely to be a threat to hatched fairy shrimp since moisture decreases fire intensity in and near vernal pools when they are filled. Hatched individuals may also be impacted by increased runoff and siltation due to reduced vegetation in watersheds which could alter pool hydrology, though vernal pool hydrology did not appear to be affected in the MCAS Miramar study (MCAS Miramar 2005). Introduction of ash and other burned/burning materials could alter water chemistry of vernal pools causing impacts to hatched fairy shrimp. Studies of post-fire water chemistry changes in other habitat types indicate fire can result in chemical alterations such as elevated pH at least in the short term (Battle and Golladay 2003), however, specific information on the potential alteration of vernal pool chemistry by fire and the impacts thereof on fairy shrimp is lacking.

More study is needed to determine the magnitude of the fire threat on San Diego fairy shrimp.

Summary of Factor E

In summary, impacts associated with fragmentation and isolation of habitat and encroaching development continue to significantly threaten this species throughout its range. Even in areas where habitat is protected, the urbanization of surrounding lands results in the fragmentation of protected habitats, likely hampering recolonization of San Diego fairy shrimp habitat where populations have been extirpated, as well as exacerbating other indirect impacts to pool complexes such as those caused by human access and disturbance. Off-highway vehicle use continues to be a significant threat to the San Diego fairy shrimp, especially on Otay Mesa, San Diego County, due to Border Patrol activities and recreation. Increased monitoring and management of habitat is needed to counteract these threats. The magnitude of the impact of pesticides, drought and climate change, and stochastic events such as fire on San Diego fairy shrimp is unclear at this time; more research is needed to determine the significance of these threats. The Service continues to work with developers, land managers, and other partners to recommend measures (e.g., fencing, signage, habitat buffers, management, etc.) to ameliorate the impact of these threats to the species.

III. RECOVERY CRITERIA

Pursuant to section 4(f) of the Act, recovery plans are developed to provide guidance to the Service, States, and other partners and interested parties on ways to minimize threats to listed species, and on criteria that may be used to determine when recovery goals are achieved. Recovery plans are required to contain objective, measurable criteria, which, when met, would result in a determination that the species be delisted. Conservation (i.e., recovery) is defined in section 3 of the Act as the “use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to this Act are no longer necessary.” In accordance with section 4(a)(1) of the Act, we determine if any species is an endangered or threatened species because of any of the five threat factors identified in the Act and evaluated in this 5-year review. Therefore, we revise the listed status of a species based on the outcome of an analysis of these five factors.

Although recovery plans are not regulatory documents, they provide a guide on how to achieve recovery based on information available at the time the recovery plan is finalized. Recovery criteria describe measurable projected outcomes or an estimated species response to a reduction or removal of the threats to a species as described in a five-factor analysis. However, reduction or removal of threats may occur without meeting all recovery criteria contained in a recovery plan, as there are many paths to accomplishing recovery of a species and recovery may be achieved without fully meeting all recovery plan criteria. For example, one or more criteria may have been exceeded, while other criteria may not have been accomplished. In other cases, recovery opportunities may have been recognized that were not known at the time the recovery plan was finalized. Likewise, we may learn information about the species or threats that was not known at the time the recovery plan was finalized. Overall, recovery is a dynamic process

requiring adaptive management, and assessing a species' degree of recovery is likewise an adaptive process that may, or may not, fully follow the guidance provided in a recovery plan.

Consistent with section 4 of the Act, determinations whether any federally listed species should be (i) removed from the list; (ii) changed in status from endangered to threatened; or (iii) changed in status from threatened to endangered will be made in accordance with an analysis of the five factors. Therefore, although we expect at the time a recovery plan is published that recovery criteria will be met, the actual determination of appropriate listing status is not based solely on whether recovery criteria have been met. Rather, progress towards fulfilling recovery criteria serves to indicate the extent to which threat factors have been reduced or eliminated. In absence of meeting recovery plan criteria, the Service may judge in some cases that the overall threats have been reduced sufficiently and the species is sufficiently robust to either reclassify the species from endangered to threatened, or delist the species.

The San Diego fairy shrimp criteria in the Recovery Plan do not reflect the most current information. The recovery criteria were developed using information available in 1998. Additional San Diego fairy shrimp occurrences have been identified since completion of the Recovery Plan, and the status of several complexes identified in Appendices F and G of the Recovery Plan has changed. Additionally, the recovery criteria do not consider the results of recent genetic studies on the San Diego fairy shrimp (Bohonak 2005), which, for example, indicate a need to consider preservation of the genetic distribution of the species at the clade level. Despite these problems with the Recovery Plan and those discussed below, the plan provides useful guidance for recovering San Diego fairy shrimp. The recovery criteria are not threats-based (i.e., formulated in the language of the Act's five threat factors), but do indirectly speak to the threats outlined in the "Five-Factor Analysis" section of this review. Overall, progress is being made toward achieving the recovery criteria, although none can be fully achieved as written (as explained below). Revision of the Recovery Plan should be considered to update species occurrences, provide threats-based recovery criteria, and address the other shortcomings of the Plan discussed within this review.

The Recovery Plan for San Diego fairy shrimp proposes a twofold strategy to recover multiple vernal pool species: 1) stabilization of the populations through procurement and management of habitat; and 2) reclassification of the species through restoration and enhancement, including recolonization and expansion of existing populations. Although we believe the Recovery Plan is outdated in some respects, we still consider this general approach appropriate for San Diego fairy shrimp conservation and recovery. The recovery criteria for stabilizing and downlisting the San Diego fairy shrimp are summarized below, and include only those portions relevant to San Diego fairy shrimp:

Criterion 1. *Existing vernal pools and their associated watersheds contained within the complexes identified in Appendix F must be secured from further loss and degradation in a configuration that maintains habitat function and species viability (as determined by prescribed research tasks) in order to maintain genetic diversity and population stability of the listed species.*

Criterion 2. *Existing vernal pools and their associated watersheds contained within the complexes identified in Appendix G of the Recovery Plan must be secured in a configuration that maintains habitat function and species viability (as determined by prescribed research tasks) before reclassification the species to threatened status may be considered.*

These recovery criteria do not explicitly address any of the threat factors identified in the Five-Factor Analysis above. Moreover, achievement of these criteria as written is complicated by the fact that some pools within the complexes identified in Appendices F and G have been developed since completion of the Recovery Plan. However, working toward the goals set in these criteria will reduce threats discussed above under Factors A and E. Securing vernal pool complexes physically, legally, and ecologically would reduce threats posed by development.

Securing complexes physically through fencing and maintaining sufficiently large habitat buffers (i.e., at least 100 feet measured from the outer edge of the watershed in most cases) reduces encroachment by pedestrians and OHV recreators, trash accumulation and dumping, and other indirect effects of development. Complexes in areas that are secured from encroachment have shown fewer of these impacts. For example, fencing and security at Montgomery Field has minimized trespassing and trash accumulation in the vernal pool complexes at that site (City of San Diego 2006). Securing complexes legally through conservation easements, other long-term agreements, or ownership transfers ensures complexes cannot be converted to development even in the event of a change in ownership, and sets out the conservation measures necessary to maintain the habitat through time. Securing complexes ecologically via enhancement of preserved vernal pools (if needed) and regular maintenance and monitoring in perpetuity will ensure complexes are not allowed to degrade over time due to vandalism (e.g., fence removal, OHV use), trash accumulation, invasive nonnative plants, or hydrological alterations.

Appendices F and G in the Recovery Plan list the complexes the Recovery Plan concluded needed to be secured, based on the information available at the time. Appendix 1 of this 5-year review lists all 137 currently occupied complexes, including those listed in Appendices F and G of the Recovery Plan as well as some that have been identified since listing and/or since the Recovery Plan was finalized, and including 3 complexes that have been extirpated since listing. Appendix 2 lists 53 complexes identified in Appendices F and G of the Recovery Plan that are currently unoccupied by San Diego fairy shrimp. Overall, the Recovery Plan indicated a total of approximately 155 complexes that should be secured, including approximately 112 complexes (74 of which are now identified as occupied) listed in Appendix F as necessary to stabilize the species, and 43 complexes (11 of which are now identified as occupied) listed in Appendix G as necessary to reclassify the species. However, these numbers are not the same as those tabulated in the Recovery Plan. Appendix F of the Recovery Plan appears to only list 49 complexes (30 occupied) and Appendix G only 25 complexes (10 occupied) because many complexes were grouped together in these two tables in ways that are not useful for implementing conservation actions on the ground. For example, all 7 of the complexes in the City of Ramona are grouped as a single complex named “Ramona” in Appendix F. The numbers assessed here (i.e., a total of 155 complexes) are considered approximate because it is at times unclear which complexes are included under the groupings in Appendices F and G of the Recovery Plan. However, as explained below, we no longer use the Recovery Plan to identify complexes for recovery purposes, but instead have created an updated database of 137 extant, occupied complexes

(Appendix 1 of this 5-year review). We provide the discussion in the paragraphs below to show how we are meeting Recovery Plan criteria for the complexes identified in the Recovery Plan. For a summary of the conservation status of extant complexes as currently identified in our updated database (Appendix 1), see the “Factor A” discussion of this review.

Of the total 155 complexes that we have identified from Recovery Plan Appendices F and G, at least 21 of the 74 occupied complexes (about 28 percent; 5 pre-listing and 16 since listing) listed in Appendix F of the Recovery Plan, and 3 of the 11 occupied complexes (27 percent; 1 pre-listing and 2 since listing) listed in Appendix G of the Recovery Plan, have been at least partially conserved. In addition, at least 36 complexes listed in Appendix F (about 49 percent), and 7 complexes listed in Appendix G (64 percent) are on military land and thus (at least partially) meet this criterion (see Appendix 1 in this 5-year review). However, long-term maintenance and monitoring for most restored and preserved vernal pools is either nonexistent, inadequate, or has not been guaranteed in perpetuity. At least 7 occupied complexes listed in Appendix F of the Recovery Plan and 1 occupied complex in Appendix G are proposed for development. At least 15 complexes listed in Appendices F and G of the Recovery Plan contain 1 or more pools that have been lost to development since listing, and 5 contain pools that have been substantially degraded by other impacts since listing (the damage caused by most of these impacts has since been remediated) (see Appendices 1 and 2 of this review). Approximately 44 complexes listed in Recovery Plan Appendices F and G occur on private lands that are not conserved or proposed for conservation.

In addition to the difficulties mentioned above, implementation of criteria 1-2 as stated in the Recovery Plan has been further complicated by the fact that the Recovery Plan does not define the term “complex” nor provide information on how Appendices F and G were derived. We cannot locate or identify many of the complexes identified in the Recovery Plan because the Plan does not contain maps or figures identifying complex locations nor does it cite an identification system. While it is likely that the Recovery Plan utilized the identification system given in Beauchamp and Cass (1979), Bauder (1986a), and Zedler et al. (1979) for many of the complexes in San Diego County, several complexes listed in Appendix E (a list of all complexes known at the time) are not included in these reports (e.g., BB2, GA, LL, U10). Additionally, locating the complexes identified in Appendices F and G is further complicated because several complexes identified in these appendices are combined in an unclear fashion from complexes listed in Appendix E (e.g., B Mira Mesa North; H 1-10, 13-15, 18-23, 33 Penasquitos North/Del Mar Mesa; Z 1-3, 6, 7, 10 Westgate Miramar; AA 1-7, 9-13 East Miramar; J2, 5, 7, 11-21, 23-30; and U15, 19 Landmark/Sander/Cubic Pools in Appendix F). Furthermore, there is no information regarding the size of complexes, amount of extant or potential San Diego fairy shrimp habitat, San Diego fairy shrimp abundance, and relative importance for each complex. Therefore, it is difficult to determine how to utilize the Recovery Plan appendices to achieve recovery (i.e., prioritizing preservation and enhancement efforts). Finally, the Recovery Plan provides no guidance on how to achieve conservation of complexes in a “configuration that maintains habitat function and species viability.” Varying climatic conditions and resulting ecological conditions combined with the lack of information on relative importance of pools within and between complexes, complicates implementation of this specific goal. Long-term maintenance and monitoring of conserved pools would help ensure the intent of this criterion is realized. Criteria 1-2 should be clarified to delineate the location of all identified complexes,

assess configurations that will maintain habitat function and species viability, and prioritize preservation and enhancement activities necessary to achieve recovery.

Although it is not possible to specifically identify every complex in Appendices F and G of the Recovery Plan on the ground, the Service strongly recommends avoidance of development impacts on all complexes. The Service is working with partners towards conserving complexes. At least 32 out of the 155 complexes (21 percent) listed in Appendices F and G (occupied and not occupied) have been at least partially conserved, and 50 are on military land (32 percent) (Appendices 1 and 2). Approximately 25 percent of the total 137 complexes currently identified as occupied by San Diego fairy shrimp have been at least partially conserved, and 51 percent are on military land where they are provided some protection (Appendix 1).

Criterion 3. *Secured vernal pools must be enhanced or restored such that population levels of existing species are stabilized or increased.*

This criterion does not directly address any of the threats to the species discussed in the Five-Factor Analysis above. Also, we do not yet possess a method of assessing San Diego fairy shrimp population levels within secured vernal pools, and therefore cannot determine whether population levels are stabilized, increasing, or decreasing in these pools. We can only determine presence or absence of adults or cysts. However, enhancing and/or restoring secured pools would ameliorate impacts from all threats under Factors A and E. The Carlsbad Fish and Wildlife Office has issued 48 biological opinions on the San Diego fairy shrimp. These opinions outline avoidance and minimization measures that include enhancement and restoration of San Diego fairy shrimp habitat. According to our records, these efforts appear to have resulted in successful restoration of vernal pool hydrology and transfer of San Diego fairy shrimp into the restored vernal pools at some sites (e.g., Arnie’s Point, Greystone Torrey Highlands, Sweetwater High School). Additionally, enhancement is planned for the vernal pools on public protected lands south of Sweetwater Reservoir on the San Diego National Wildlife Refuge, as well as for vernal pools at Kearny Mesa, Proctor Valley, Spring Canyon, east and west Otay Mesa, and Marron Valley. Therefore, we believe this criterion is being achieved in certain areas within the species’ range, and will be achieved in other areas in the future. Long-term monitoring of restored pools will help demonstrate the persistence of San Diego fairy shrimp.

Criterion 4. *Population trends must be shown to be stable or increasing for a minimum of 10 consecutive years prior to consideration for reclassification.*

This criterion does not directly address any of the threats to the species discussed in the Five-Factor Analysis above. However, working toward the goal set in this criterion will reduce threats discussed above under Factors A and E. As discussed above, we currently are unable to quantify numbers of San Diego fairy shrimp within vernal pools, and therefore cannot determine whether actual population levels are stabilized, increasing, or decreasing. Research directed toward establishing methodologies to monitor fairy shrimp abundance are being conducted (see the “Species-specific Research and/or Grant-supported Activities” section, above), and we recommend further studies below in section VI (“Recommendations for Actions over the Next 5 Years”).

IV. SYNTHESIS

San Diego fairy shrimp was listed in 1997 primarily due to the threat of development throughout the range of the species. At the time of listing it was estimated that 90 to 97 percent of its historical habitat in San Diego County had been destroyed (Bauder 1986a, Oberbauer and Vanderwier 1991; Keeler-Wolf et al. 1995) and that similar declines had occurred elsewhere (Keeler-Wolf et al. 1995; Ferren and Pritchett 1988). The remaining habitat that was not protected was threatened by development. At the time the listing rule was written, we were only aware of an estimated 25 vernal pool complexes within the U.S. that were known to be occupied by the San Diego fairy shrimp. All occupied areas were considered to be under imminent threat of development or other impacts. The impacts of development on San Diego fairy shrimp and its habitat have been reduced by the protections afforded the species by the Endangered Species Act. Despite protections, since listing at least 3 occupied vernal pool complexes have been lost of the overall total of 140 identified in our current database.

The overall distribution of complexes known to be occupied by San Diego fairy shrimp has increased since listing from an estimated 25 occupied complexes to approximately 137 known today. These additional occurrences were likely in existence at the time the species was listed, but had not been identified by surveys and therefore were not included in the analyses that led to the listing of the species. The species has also been introduced into restored vernal pools as part of vernal pool restoration projects: portions of at least 17 complexes have been restored since listing (compared to the 3 complexes that have been lost). The additional occurrences increase the potential for conservation and recovery of San Diego fairy shrimp as these additional occurrences contribute to the resilience of this species via population redundancy; i.e., more populations are known to be available to contribute to sustaining the species in the event some populations are extirpated.

Approximately 23 percent of occupied complexes occur on private lands with no conservation in place, making them vulnerable to development as well as other impacts without the protection of the Act. According to Service files, currently proposed development is expected to impact at least 24 occupied vernal pool complexes (approximately 18 percent of occupied complexes).

Approximately 38 percent of known occupied complexes occur on military lands, including 9 complexes on MCB Camp Pendleton and 39 complexes on MCAS Miramar, which supports the largest contiguous block of habitat and highest number of occupied vernal pools within the range of the San Diego fairy shrimp. Vernal pool sites on military lands are not considered completely protected because many pools on MCB Camp Pendleton occur in active training areas. However, these lands are managed in part for San Diego fairy shrimp pursuant to section 7 consultations and implementation of INRMPs. The Marine Corps has initiated a study to evaluate the impact of tracked vehicle training on fairy shrimp; results of this study will help determine the threat level and ultimate recovery potential of San Diego fairy shrimp on military lands.

Approximately 25 percent of occupied vernal pool complexes have been conserved and are protected from land-use conversion. However, almost all of the conserved lands are in need of guaranteed long-term management, improved management, restoration, or enhancement. For

example, although several regional HCPs are in place which are expected to conserve San Diego fairy shrimp within plan boundaries, implementation of these plans has not yet met the conservation goals for San Diego fairy shrimp to ensure its protection and long-term management and monitoring. Further, the long-term viability of restoration and preservation/enhancement projects has been called into question by some researchers familiar with the species and its habitat (e.g., Simovich 1998). It is possible that in some instances, San Diego fairy shrimp transplanted into restored pools do not form a viable cyst bank and over time may not persist in the pools. Simovich (1998) recommends that quantitative and qualitative monitoring of restored vernal pools continue beyond 5 years to establish the success of restoration projects with certainty.

All remaining San Diego fairy shrimp habitat is threatened to some degree by indirect impacts of development (including OHV use and other human access and disturbance impacts, runoff, dumping of trash and litter, and water and air pollution) resulting from the proximity of San Diego fairy shrimp habitat to development. Off-highway vehicle use by recreators, law enforcement (including Border Patrol), and the military threatens this species throughout much of its range. Nonnative plant also threaten San Diego fairy shrimp habitat throughout the range of the species. San Diego fairy shrimp habitat is naturally fragmented, but development projects continue to further fragment and isolate vernal pools within and between complexes, which may disrupt the population dynamics of the species. Conservation measures beyond habitat preservation, such as habitat and species management and monitoring, are necessary to ensure the long-term sustainability and persistence of this species throughout its range.

Until we have better knowledge about the extent of site-specific threats to this species and its habitat, we recommend retaining the current Endangered Species Act classification for the San Diego fairy shrimp. Completion of the Marine Corps' study evaluating the impact of tracked vehicle training on fairy shrimp will help determine the threat level and ultimate recovery potential of San Diego fairy shrimp on MCB Camp Pendleton. Furthermore, we expect additional conservation and management and enhancement of occupied habitat will occur as regional HCPs are implemented through time. Demonstrated progress towards meeting the species-specific conservation goals of the regional HCPs will address the threat of development and address the long term management and monitoring needs in those areas. In section IV below, we recommend actions that, over the next 5 years, would provide additional information needed to better assess the current status and threats to the species. The threats identified above, and the need for more information regarding the effects of these impacts on species fitness and demographics, continue to place this species at risk of extinction. For these reasons, we conclude that San Diego fairy shrimp continues to meet the definition of endangered and recommend no change in listing status.

V. RESULTS

Recommended Listing Action:

- Downlist to Threatened
- Uplist to Endangered
- Delist (indicate reason for delisting according to 50 CFR 424.11):
 - Extinction*
 - Recovery*
 - Original data for classification in error*
- No Change

New Recovery Priority Number and Brief Rationale: No Change

VI. RECOMMENDATIONS FOR ACTIONS OVER THE NEXT 5 YEARS

Implementation of recommendations 1-3 would provide information that would allow us to consider the potential downlisting of this species:

1. Support continued conservation, enhancement, management, and monitoring of vernal pool habitat, including monitoring of restored/enhanced habitat to determine if vernal pool restoration projects continue to be viable through time (e.g., artificial clay layer remains stable and supports adequate ponding).
2. Support completion and peer review of Marine Corps' study evaluating the impact of tracked vehicle training on fairy shrimp, and develop conservation measures based on the results.
3. Determine the extent of all remaining occupied habitat, including status (e.g., conserved, restored, managed, monitored, impacted, illegally impacted) and needs (e.g., conservation, restoration, management, monitoring) categories for all San Diego fairy shrimp habitat complexes. Utilize this information to update Appendix 1 of this review. Cross-reference Appendix 1 of this review with the appendices to the Recovery Plan and the Bauder (1986a) identification system
4. Track past and present use of vernal pool inoculum in San Diego fairy shrimp habitat restoration projects. Determine degree of genetic risk (contamination) of past reintroduction of San Diego fairy shrimp into restored pools and enhanced vernal pools, and determine remediation triggers and methods.
5. Develop protocols for quantitative estimates of adult and cyst abundance, as feasible, and define ranges within which –
 - a. cyst banks would be considered adequately populated; and
 - b. adult numbers (given sufficient pooling) reflect a healthy population.The San Diego fairy shrimp survey protocol should be updated to include collection of such abundance data. The defined abundance ranges should be used to model a population

viability analysis (PVA) for San Diego fairy shrimp, and as standards for determining San Diego fairy shrimp habitat restoration success.

6. Consider revising the Recovery Plan to incorporate new information and address issues discussed in “Recovery Criteria” section of this review. Recovery criteria should include PVA and genetic information available for the San Diego fairy shrimp to help determine which areas should be preserved and to guide translocation efforts. Recovery criteria should include quantifiable thresholds for downlisting and delisting.

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Appendix 1. Vernal pool complexes identified as occupied at listing of San Diego fairy shrimp in 1997 (62 FR 4925) and since listing.

Complex Name	Location	Ownership	Status	Major Threats	Needs	Occupied	Recovery Plan Appendix
Fairview Park (CNDDDB occurrence number 11) (Bomkamp 2001)	City of Costa Mesa, Orange County	City of Costa Mesa	conserved, mitigation	nonnative plants, mowing, <i>Branchinecta lindahli</i> (M. Simovich, professor, University of San Diego, pers. comm., 2004), fragmentation	restoration, management	X (Service 1998a; CNDDDB 2008)	F
Newport Banning Ranch++	Orange County (City of Costa Mesa)	Private	proposed development	development	conservation, restoration, management	X+ (Glenn Lukos Associates 2000)	
Chiquita Ridge	Orange County (Unincorporated)	Private	conserved (Dudek & Associates 2006c; Service 2007b, 1996a)	nonnative plants, fire control	restoration, management	X+ (Dudek & Associates 2001a)	
Radio Tower Road++	Orange County (Unincorporated)	Private	conserved (Dudek & Associates 2006c; Service 2007b)	nonnative plants, grazing, fire control	restoration, management	X+ (Dudek & Associates 2001a)	
Irvine Ranch Land Reserve++	Orange County (Unincorporated)	Private	conserved		management	X+ (Harmsworth Associates 2007)	
H38++ (Carmel Mountain) (City of San Diego 2006)	Del Mar Mesa, City of San Diego, San Diego County	City of San Diego	conserved	nonnative plants, OHV, fire control	restoration, management	X+ (City of San Diego 2004)	
H39++ (Greystone Torrey Highlands) (City of San Diego 2004, 2006)	Del Mar Mesa, City of San Diego, San Diego County	Private	partially developed; remainder conserved, restored (Service 2000a)	nonnative plants, fragmentation, <i>Branchinecta lindahli</i>	management	X+ (EDAW 2007)	

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H?, Subarea 3	Del Mar Mesa, City of San Diego, San Diego County	Private	partially conserved, partially developed	unknown	unknown	X (Service 1998a)	
H4-10 (Del Mar Mesa) (City of San Diego 2006)	Del Mar Mesa, City of San Diego, San Diego County	CDFG - SR 52 mitigation/ Service	conserved, mitigation (Service 1989), National Wildlife Refuge	nonnative plants, OHV, fire control	restoration, management	X+ (City of San Diego 2004)	F
H13-15 (Del Mar Mesa) (City of San Diego 2006)	Del Mar Mesa, City of San Diego, San Diego County	CDFG - SR 52 mitigation	conserved, mitigation (Service 1989), National Wildlife Refuge	nonnative plants, OHV, fire control	restoration, management	X+ (City of San Diego 2004)	F
H17 (Shaw Texas) (City of San Diego 2004, 2006)	Del Mar Mesa, City of San Diego, San Diego County	Private	proposed development (Service 2006)	development, OHV, nonnative plants, fragmentation	conservation, restoration, management	X+ (Glenn Lukos Associates 2005a)	
H18-23 (City of San Diego 2004, 2006)	Del Mar Mesa, City of San Diego, San Diego County	CDFG - SR 52 mitigation/ Service	conserved, mitigation (Service 1989), National Wildlife Refuge	nonnative plants, OHV, fire control	management	X+ (Helix 1998a, 2000)	F
H24-26 (Rhodes, portion of Del Mar Mesa) (City of San Diego 2006)	Del Mar Mesa, City of San Diego, San Diego County	Private	proposed development	development, OHV, nonnative plants, fragmentation	conservation, restoration, management	X+ (Helix 1998a, 2000)	
H33 (City of San Diego 2006)	Del Mar Mesa, City of San Diego, San Diego County	San Diego Gas and Electric	conserved (Service 1995b)	nonnative plants, OHV, fire control	restoration, management	X+	F
H36, Subarea 5 (Shaw Texas) (City of San Diego 2006)	Del Mar Mesa, City of San Diego, San Diego County	Private	proposed development (Service 2006)	development, OHV, nonnative plants, fragmentation	conservation, management	X+ (Glenn Lukos Associates 2005a)	

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Complex Name	Location	Ownership	Status	Major Threats	Needs	Occupied	Recovery Plan Appendix
BB/BB2 (New Century Center in Appendix G only)/ (General Dynamics) (City of San Diego 2006)	Kearny Mesa, City of San Diego, San Diego County	Private	partially developed; remainder conserved, restored (Service 1998b)			X (Service 1998a)	G
G1 (Murphy Canyon) (CNDDDB occurrence number 15))	Kearny Mesa, City of San Diego, San Diego County	U.S. Navy	DOD partially restored, mitigation (Service 1995a, 2003a)	nonnative plants, OHV, fire control	management, fencing	X (RECON 1998, 2003; CNDDDB 2008)	F
G2 (Murphy Canyon) (CNDDDB occurrence number 15)	Kearny Mesa, City of San Diego, San Diego County	U.S. Navy	DOD partially restored, mitigation (Service 1995a, 2003a)	nonnative plants, OHV, fire control	management, fencing	X (RECON 1998, 2003; CNDDDB 2008)	F
I1 (Arjons) (City of San Diego 2006)	Kearny Mesa, City of San Diego, San Diego County	Private/City of San Diego easement	conserved, 8 pools impacted in 1999 by unauthorized grading	nonnative plants, OHV, fragmentation	restoration, management	X+ (City of San Diego 2004)	
I12 (Pueblo Lands) (City of San Diego 2006)	Kearny Mesa, City of San Diego, San Diego County	City of San Diego	not preserved	development, nonnative plants, fragmentation	conservation, restoration management	X+ (City of San Diego 2004)	
N1-4, 6 (Montgomery Field) (City of San Diego 2006)	Kearny Mesa, City of San Diego, San Diego County	City of San Diego	partially developed pre-listing (Service 1994)	development, nonnative plants, emergency response	conservation, restoration, management	X+ (City of San Diego 2004)	F
N7++ (Serra Mesa Library) (CNDDDB occurrence number 54) (City of San Diego 2004, 2006)	Kearny Mesa, City of San Diego, San Diego County	City of San Diego	partially developed; remainder conserved	nonnative plants, fragmentation	restoration, management	X+ (CNDDDB 2008)	

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Complex Name	Location	Ownership	Status	Major Threats	Needs	Occupied	Recovery Plan Appendix
N8++ (General Dynamics; same as BB and BB2?) (City of San Diego 2006)	Kearny Mesa, City of San Diego, San Diego County	Private	conserved, mitigation site (Service 1998b)	nonnative plants, fragmentation	management	X+ (City of San Diego 2004)	
U15 (Sander) (City of San Diego 2006)	Kearny Mesa, City of San Diego, San Diego County	City of San Diego	not preserved (Service 1988 (project not constructed), 1996b)	development, fragmentation	conservation, restoration, management	X (Service 1998a; City of San Diego 2004)	G
U15 (Miramar)	MCAS Miramar, San Diego County	U.S. Marine Corps	mitigation, restored, covered by MCAS Miramar INRMP (Service 1996b)	nonnative plants, fragmentation	management	X (Service 1998a; City of San Diego 2004)	G
X5 (Nobel Drive) (City of San Diego 2006)	Kearny Mesa, City of San Diego, San Diego County	City of San Diego	conserved pre-listing	nonnative plants, fragmentation	restoration, management	X+ (City of San Diego 2004)	F
Mission Valley ++ (CNDDDB occurrence number 56)	Kearny Mesa, City of San Diego, San Diego County	Private	not preserved	development, fragmentation	conservation, restoration, management	X+ (CNDDDB 2008)	
X7++ (Nobel Research Park) (City of San Diego 2006)	Kearny Mesa, City of San Diego, San Diego County	Private	conserved pre-listing	nonnative plants, fragmentation	restoration, management	X+ (City of San Diego 2004)	
Chollas Heights	City of San Diego, San Diego County	U.S. Navy	DOD partially developed pre-listing; remainder restored, mitigation (Service 1995a, 2003a)	nonnative plants, OHV, fire control	management	X (Service 1998a)	F
B2 (unsure of location)	Mira Mesa, City of San Diego, San Diego County	Private	unknown			X (Service 1998a)	F

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Complex Name	Location	Ownership	Status	Major Threats	Needs	Occupied	Recovery Plan Appendix
B11 (Mesa Norte) (City of San Diego 2006)	Mira Mesa, City of San Diego, San Diego County	Private	conserved, restored, mitigation (Service 1998c)	nonnative plants, fragmentation	management	X+ (City of San Diego 2004)	F
B5 (Lopez Ridge) (City of San Diego 2006)	Mira Mesa, City of San Diego, San Diego County	City of San Diego	conserved pre-listin, mitigation (Service 1988)	nonnative plants, fire control	restoration, management	X (Service 1998a; City of San Diego 2004)	F
B6 (Tierra Alta) (City of San Diego 2006)	Mira Mesa, City of San Diego, San Diego County	City of San Diego	conserved, mitigation	nonnative plants, fire control	restoration, management	X (Service 1998a; City of San Diego 2004)	F
B7-8E (Brown Parcel) (considered part of Lopez Ridge in City of San Diego 2006)	Mira Mesa, City of San Diego, San Diego County	City of San Diego	conserved pre-listing, mitigation	nonnative plants, fire control	restoration, management	X (Service 1998a; City of San Diego 2004)	F
B7-8W (Crescent Heights) (City of San Diego 2004, 2006)	Mira Mesa, City of San Diego, San Diego County	Private	proposed development	development, fragmentation	conservation, restoration, management	X (Service 1998a)	F
C10-16, 26 (Winterwood Park) (City of San Diego 2006)	Mira Mesa, City of San Diego, San Diego County	City of San Diego	partially conserved pre-listing, partially illegally impacted pre-listing by adjacent construction of school; proposed mitigation site	OHV, nonnative plants, fragmentation	conservation, restoration, management	X (Service 1998a; City of San Diego 2004)	F
C27 (Cousins Market Center)	Mira Mesa, City of San Diego, San Diego County	Private	partially (mostly) developed, 1 pool conserved (Service 1998c)			X (Service 1998a; City of San Diego 2004)	
Maddox Park (C28 in City of San Diego 2004) (City of San Diego 2006)	Mira Mesa, City of San Diego, San Diego County	San Diego Unified School District	proposed development	development, OHV, nonnative plants, fragmentation	conservation, restoration, management	X (Service 1998a; City of San Diego 2004; Merkel and Associates 2002a, b)	

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Complex Name	Location	Ownership	Status	Major Threats	Needs	Occupied	Recovery Plan Appendix
D5-6 (D5-8 in Appendix F and Carroll Canyon/Parkdale Carroll Canyon in City of San Diego 2004) (City of San Diego 2004, 2006)	Mira Mesa, City of San Diego, San Diego County	City of San Diego	119 pools conserved pre-listing, managed as mitigation; 4 pools not preserved (Service 1983)	development, nonnative plants, OHV, nonnative plants, fragmentation	conservation, restoration, management of 4 pools	X+	F
I7 - Eastgate Mall/Miramar Industrial	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1, restored, covered by MCAS Miramar INRMP	nonnative plants, fragmentation	restoration, management	X (Service 1998a; Merkel and Associates 2001, 2003; Black 2007a)	F
A4, Tierrasanta	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1, covered by MCAS Miramar INRMP	nonnative plants, fire control, military activities	restoration, management	X (Service 1998a; Black 2007a)	F
AA1 east	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD, covered by MCAS Miramar INRMP	nonnative plants, fire control, military activities	restoration, management	X (Service 1998a)	F
AA1 south	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1, restored, mitigation site, covered by MCAS Miramar INRMP (Service 1992)	nonnative plants, fire control, military activities	restoration, management	X (Service 1998a; Black 2007a)	F
AA1 west	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1, covered by MCAS Miramar INRMP	nonnative plants, fire control, military activities	restoration, management	X (Service 1998a)	F
AA10	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1, covered by MCAS Miramar INRMP	nonnative plants, fire control, military activities	restoration, management	X (Service 1998a)	F

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Complex Name	Location	Ownership	Status	Major Threats	Needs	Occupied	Recovery Plan Appendix
AA12 north+	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 5, covered by MCAS Miramar INRMP	nonnative plants, fire control, military activities	restoration, management	X+ (Black 2004, 2007a)	F
AA13	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1, covered by MCAS Miramar INRMP	nonnative plants, fire control, military activities	restoration, management	X+ (MCAS Miramar 2006b)	F
AA3	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1, covered by MCAS Miramar INRMP	nonnative plants, fire control, military activities	restoration, management	X (Service 1998a; Black 2007a)	F
AA4-7	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1, mitigation, covered by MCAS Miramar INRMP (Service 1996b)	nonnative plants, fire control, military activities	restoration, management	X (Service 1998a; Black 2007a)	F
AA8	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1, covered by MCAS Miramar INRMP	nonnative plants, fire control, military activities	restoration, management	X (Service 1998a; Black 2007a)	G
AA9	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1, covered by MCAS Miramar INRMP	nonnative plants, fire control, military activities	restoration, management	X (Service 1998a; Black 2007a)	F
EE1	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA, covered by MCAS Miramar INRMP	nonnative plants, fire control, military activities	restoration, management	X (Ogden 1994; Service 1998a; Black 2004)	F
EE2	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1, partially developed, restored (Service 1996b)	nonnative plants, fire control, military activities	restoration, management	X+ (Ogden 1994; Black 2004)	F

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Complex Name	Location	Ownership	Status	Major Threats	Needs	Occupied	Recovery Plan Appendix
F north (F1-27 in Appendix F)	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1, partially developed, mitigation, covered by MCAS Miramar INRMP (Service 1996b)	nonnative plants, fire control, military activities	restoration, management	X+ (Black 2004)	F
F16-17	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1, mitigation, covered by MCAS Miramar INRMP (Service 1996b)	nonnative plants, fire control, military activities	restoration, management	X (Service 1998a; Black 2005a)	
FF1-2	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 4, partially developed, covered by MCAS Miramar INRMP (Service 1996b)	nonnative plants, fire control, military activities	restoration, management	X (Service 1998a; Black 2004)	G
GA	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1, covered by MCAS Miramar INRMP	nonnative plants, fire control, military activities	restoration, management	X (Ogden 1994; Service 1998a)	
GG1	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1, partially developed, covered by MCAS Miramar INRMP (Service 1996b)	nonnative plants, fire control, military activities	restoration, management	X (Ogden 1994; Service 1998a; Black 2004)	
GG2+	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1, partially developed, covered by MCAS Miramar INRMP (Service 1996b)	nonnative plants, fire control, military activities	restoration, management	X (Ogden 1994; Service 1998a; Black 2005a)	

Appendix 1. Vernal pool complexes identified as occupied at listing of San Diego fairy shrimp in 1997 (62 FR 4925) and since listing.

Complex Name	Location	Ownership	Status	Major Threats	Needs	Occupied	Recovery Plan Appendix
GG3+	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 3, partially developed, covered by MCAS Miramar INRMP (Service 1996b)	nonnative plants, fire control, military activities	restoration, management	X+ (Ogden 1994; Black 2004)	
HH1+	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1, restoration site, covered by MCAS Miramar INRMP (Service 1995c)	nonnative plants, fire control, military activities	restoration, management	X (Ogden 1994; Service 1998a)	F
HH2+	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1, covered by MCAS Miramar INRMP	nonnative plants, fire control, military activities	restoration, management	X (Ogden 1994; Service 1998a; Black 2004)	F
HH3+	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 2, partially developed, partially restored (80% filled, 20% restored), covered by MCAS Miramar INRMP (Service 1996b)	nonnative plants, fire control, military activities	restoration, management	X (Ogden 1994; Service 1998a)	F
RR2	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1, covered by MCAS Miramar INRMP	nonnative plants, fire control, military activities	restoration, management	X (Service 1998a; Black 2007a)	F
U North (U 1-13 Landmark/U-North in Appendix F)	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1, partial restoration site, covered by MCAS Miramar INRMP	nonnative plants, fire control, military activities	restoration, management	X (Service 1998a; Black 2007a)	F

Appendix 1. Vernal pool complexes identified as occupied at listing of San Diego fairy shrimp in 1997 (62 FR 4925) and since listing.

Complex Name	Location	Ownership	Status	Major Threats	Needs	Occupied	Recovery Plan Appendix
U19 (Cubic) (City of San Diego 2004, 2006)	MCAS Miramar, San Diego County	Private/U.S. Marine Corps	private portion partially restored, remainder covered by MCAS Miramar INRMP (Service 1996b)	development, nonnative plants, fire control, fragmentation	conservation, restoration, management on private land; management on restoration site	X (Service 1998a)	G
W4 (CNDDDB occurrence number 4)	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1, partially developed pre-listing, covered by MCAS Miramar INRMP (Service 1995d)	nonnative plants, fire control, military activities		X+ (CNDDDB 2008)	
Rose Canyon++	Kearny Mesa, City of San Diego, San Diego County	San Diego Gas and Electric	proposed development	development, OHV, nonnative plants, fire control	conservation, restoration, management	X+ (Dudek & Associates 2003)	
X1-4 (West Miramar)	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1, BRIG mitigation site, covered by MCAS Miramar INRMP (Service 1987, 2007c)	nonnative plants, fire control, military activities	restoration, management	X (Service 1998a)	
Z10	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 5; partially developed, partially restored (90 percent filled, 10 percent restored), covered by MCAS Miramar INRMP (Service 1996b)	nonnative plants, fire control, military activities		X+ (Ogden 1994; Black 2005a)	F
Z1-3	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1, covered by MCAS Miramar INRMP	nonnative plants, fire control, military activities		X (Ogden 1994; Service 1998a; Black 2007a)	F

Appendix 1. Vernal pool complexes identified as occupied at listing of San Diego fairy shrimp in 1997 (62 FR 4925) and since listing.

Complex Name	Location	Ownership	Status	Major Threats	Needs	Occupied	Recovery Plan Appendix
Z6-7	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 5; partially developed, partially restored 10 percent filled, 90 percent restored, covered by MCAS Miramar INRMP (Service 1996b)	nonnative plants, fire control, military activities		X (Ogden 1994; Service 1998a; Black 2004, 2005a)	F
Z9	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 5; partially developed, partially restored (70 percent filled, 30 percent restored), covered by MCAS Miramar INRMP (Service 1996b)	nonnative plants, fire control, military activities		X+ (Black 2005a)	
RR1	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1, covered by MCAS Miramar INRMP	nonnative plants, fire control, military activities	restoration, management	X (Black 2007a)	F
V (V1-4; Sim J. Harris in Appendix F?)	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1, covered by MCAS Miramar INRMP			X (Black 2007a)	F
W1-2	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1, covered by MCAS Miramar INRMP			X (Black 2007a)	F
W3	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1, covered by MCAS Miramar INRMP			X (Black 2007a)	F

Appendix 1. Vernal pool complexes identified as occupied at listing of San Diego fairy shrimp in 1997 (62 FR 4925) and since listing.

Complex Name	Location	Ownership	Status	Major Threats	Needs	Occupied	Recovery Plan Appendix
AA11	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1, covered by MCAS Miramar INRMP	nonnative plants, fire control, military activities	restoration, management	X (Black 2007a; Ogden 1994)	F
Q2++ (Mission Trails Regional Park, including CNDDDB occurrence number 56) (City of San Diego 2006)	Mission Trails Regional Park, City of San Diego, San Diego County	City of San Diego/San Diego Water Authority/San Diego Unified School District)	proposed development, partially conserved pre-listing	development, nonnative plants, fire control	conservation, restoration, management	X+ (City of San Diego 2004; Black 2006; CNDDDB 2008)	
CC (Poway)	City of Poway, San Diego County	Private	proposed development	development, fragmentation	conservation, restoration, management	X+ (Dudek and Associates 2002)	
DD6++ (4S Ranch-Crosby Estates)	Santa Fe Valley, Unincorporated San Diego County	Private	partially developed and remainder conserved, restored	nonnative plants, fragmentation	management	X+ (Helix 1998b, 2004a)	
Q1	City of Santee, San Diego County	Grossmont College	proposed development	development, nonnative plants, fragmentation	conservation, restoration, management	X? (Service 1998a)	
Castlerock++	City of Santee, San Diego County	Private	proposed development	development, OHV, nonnative plants, fragmentation	conservation, restoration, management	X+ (Glenn Lukos Associates 2005b, 2007)	
Fanita Ranch++	City of Santee, San Diego County	Private	proposed development	development, OHV, nonnative plants, fragmentation	conservation, restoration, management	X+ (Dudek & Associates 2004, 2005)	
U10 (unsure of location)	Kearny Mesa, City of San Diego, San Diego County	Private	unknown	unknown	unknown	X (Service 1998a)	
Hwy 67 & Kalbaugh area	City of Ramona, San Diego County	Private	not preserved	development, OHV, nonnative plants, fragmentation	conservation, restoration, management	X (Service 1998a)	F

Appendix 1. Vernal pool complexes identified as occupied at listing of San Diego fairy shrimp in 1997 (62 FR 4925) and since listing.

Complex Name	Location	Ownership	Status	Major Threats	Needs	Occupied	Recovery Plan Appendix
Montecito Road (on Montecito Ranch property?)	City of Ramona, San Diego County	Private	not preserved, unauthorized impacts - clearing	development, OHV, nonnative plants, fragmentation	conservation, restoration, management	X (Service 1998a; Helix 2003a)	F
Ramona High School	City of Ramona, San Diego County	Ramona School District	unauthorized impacts (discing, mowing, vehicle traffic), proposed development	development, OHV, nonnative plants, fragmentation	conservation, restoration, management	X (Service 1998a; Black 2007b)	F
Ramona, T (T Ramona in Appendix G)	City of Ramona, San Diego County	County of San Diego	partially developed; partially restored, conserved (Service 1998d, 2001a)	nonnative plants, emergency response	restoration, management	X (Service 1998a)	F, G
Ramona Grasslands/TNC++	City of Ramona, San Diego County	The Nature Conservancy	conserved	nonnative plants, fire control	restoration, management	X+ (RECON 2005)	
Ta, Hwy 67 & 15th (SE) (Ramona Post Office)	City of Ramona, San Diego County	U.S. Postal Service	developed (Service 1997a)			Xh	F
Tb, Hwy 67 & Hunter (SE)	City of Ramona, San Diego County	Private	not preserved	development, OHV, nonnative plants, fragmentation	conservation, restoration, management	X (Service 1998a)	F
Tc, La Brea & Kalbaugh (SE)	City of Ramona, San Diego County	Private	conserved as mitigation for post office (Service 1997a)	nonnative plants, OHV, nonnative plants, fragmentation	management	X (Service 1998a)	F
L11-13 (Fry's Bent Ave)	City of San Marcos, San Diego County	Private	conserved, mitigation	nonnative plants, fragmentation	restoration, management	X	F
L15+ Armolite North/Copley Property	City of San Marcos, San Diego County	Private	proposed development	development, OHV, nonnative plants, fragmentation	conservation, restoration, management	X+? Branchinecta.cysts only (Dudek & Associates 1999a)	G

Appendix 1. Vernal pool complexes identified as occupied at listing of San Diego fairy shrimp in 1997 (62 FR 4925) and since listing.

Complex Name	Location	Ownership	Status	Major Threats	Needs	Occupied	Recovery Plan Appendix
L1-6 (Upham)	City of San Marcos, San Diego County	Private	partially developed	development, OHV, nonnative plants, fragmentation	conservation, management of remaining pools	X+ (Dudek & Associates 2006a)	F
L9-10 (Superior Ready Mix, Universal Boot)	City of San Marcos, San Diego County	Private/City of San Marcos	proposed development	development, OHV, nonnative plants, fragmentation	conservation, restoration, management	X+	F
Habib++	City of Ramona, San Diego County	Private	not preserved, unauthorized impacts in 2003; pools damaged, but not lost; not actively restored (M. Moreno, Service, pers. comm. 2008)	development, OHV, nonnative plants, fragmentation	conservation, restoration, management	X+	
Oak Country Estates++	City of Ramona, San Diego County	Private	proposed for preservation as part of Oak Country Estates project	nonnative plants, fire control, OHV, fragmentation	conservation, restoration, management	X+ (Black 2003))	
Cockleburr Mesa (RECON 2001a)	MCB Camp Pendleton, San Diego County	U.S. Marine Corps	DOD, covered by MCB Camp Pendleton INRMP	military activities, nonnative plants, fire control	conservation, restoration, management	X (Service 1998a; MCB Camp Pendleton 2007)	F

Appendix 1. Vernal pool complexes identified as occupied at listing of San Diego fairy shrimp in 1997 (62 FR 4925) and since listing.

Complex Name	Location	Ownership	Status	Major Threats	Needs	Occupied	Recovery Plan Appendix
Las Pulgas (RECON 2001a)	MCB Camp Pendleton, San Diego County	U.S. Marine Corps	DOD covered by MCB Camp Pendleton INRMP, some pools developed/ impacted by Base development and other activities covered by section 7 consultations (Service 1996c, 2000b, 2003a, b, 2005a, b)	military activities, nonnative plants, fire control	conservation, restoration, management	X (Service 1998a; MCB Camp Pendleton 2007)	F
O'Neill (RECON 2001a)	MCB Camp Pendleton, San Diego County	U.S. Marine Corps	DOD, covered by MCB Camp Pendleton INRMP	military activities, nonnative plants, fire control	conservation, restoration, management	X (Service 1998a; MCB Camp Pendleton 2007)	G
San Mateo (RECON 2001a)	MCB Camp Pendleton, San Diego County	U.S. Marine Corps	DOD, some pools developed, covered by section 7 consultations, covered by MCB Camp Pendleton INRMP	military activities, nonnative plants, fire control	conservation, restoration, management	X (Service 1998a; MCB Camp Pendleton 2007)	F
Papa Three++	MCB Camp Pendleton, San Diego County	U.S. Marine Corps	DOD, impacts authorized but have not yet taken place, covered by MCB Camp Pendleton INRMP (Service 2005a)	military activities, nonnative plants, fire control, <i>Branchinecta lindahli</i>	conservation, restoration, management	X+ potential hybrids present (SAIC 2004; MCB Camp Pendleton 2005)	
State Park Lease Area (RECON 2001a)	MCB Camp Pendleton, San Diego County	U.S. Marine Corps	DOD, covered by MCB Camp Pendleton INRMP,	nonnative plants	conservation, restoration, management	X (Service 1998a)	F

Appendix 1. Vernal pool complexes identified as occupied at listing of San Diego fairy shrimp in 1997 (62 FR 4925) and since listing.

Complex Name	Location	Ownership	Status	Major Threats	Needs	Occupied	Recovery Plan Appendix
Range 409++ (Golf) (CNDDDB occurrence numbers 34 and 35)	MCB Camp Pendleton, San Diego County	U.S. Marine Corps	DOD, covered by MCB Camp Pendleton INRMP impacted? (Service 2001)	military activities, nonnative plants, fire control	conservation, restoration, management	X+ (EDAW 2002; CNDDDB 2008)	
Stuart Mesa (RECON 2001a)	MCB Camp Pendleton, San Diego County	U.S. Marine Corps	DOD, covered by MCB Camp Pendleton INRMP, some pools developed covered by section 7 consultations (Service 2004a)	military activities, nonnative plants, fire control	conservation, restoration, management	X (Service 1998a; MCB Camp Pendleton 2007)	F
Wire Mountain (Y1-6) (RECON 2001a)	MCB Camp Pendleton, San Diego County	U.S. Marine Corps	4 pools developed) (unauthorized); loss offset via restoration, covered by MCB Camp Pendleton INRMP	military activities, nonnative plants, fire control	conservation, restoration, management	X (Service 1998a; MCB Camp Pendleton 2007)	F
JJ2 (Poinsettia Train Station; Water's End/Dunn/Poinsettia Shores)	City of Carlsbad, San Diego County	North County Transit District; Private	impacted by construction at train station; partially restored; conserved	nonnative plants, fragmentation	restoration, management	X (Service 1998a; Dudek & Associates 1998)	F
JJ1 (Palomar Point/Hieatt/Jett & San Diego County Airport)	Carlsbad, San Diego County	Palomar Point/Hieatt/ Jett/ San Diego County	watershed of one pool impacted by construction on-site, partially restored, conserved mitigation	nonnative plants, fragmentation	easement, management	X	F
JJ4 ++ Manzanita Partners	City of Carlsbad, San Diego County	Private	conserved (Service 1999a)	nonnative plants, fragmentation	easement, management	X+ (Dudek & Associates 1999b, 2006b)	

Appendix 1. Vernal pool complexes identified as occupied at listing of San Diego fairy shrimp in 1997 (62 FR 4925) and since listing.

Complex Name	Location	Ownership	Status	Major Threats	Needs	Occupied	Recovery Plan Appendix
Naval Radar Receiving Facility, Imperial Beach (in Appendix G only)	U.S. Navy Radar Receiving Facility, San Diego County	U.S. Navy	DOD	military activities, nonnative plants	restoration, management	X+ (Cobb 2001; Cobb and O'Conner 2003; Black 2005b)	G
Marron Valley (MM1 in City of San Diego 2004) (CNDDDB occurrence number 28) (City of San Diego 2004, 2006)	Marron Valley, City of San Diego, San Diego County	City of San Diego	conserved pre-listing	OHV, nonnative plants, fire control	restoration, management	X+ (CNDDDB 2008; Conservation Biology Institute 2001)	
J4-7 (Robinhood Ridge, not including mitigation pools; J7 portion of complex extirpated by development) (City of San Diego 2006)	Otay Mesa, City of San Diego, San Diego County	Private	partially developed, remainder conserved, restored (Service 1998e)	nonnative plants, fragmentation	management	X+ (Helix 1997; Service 1998a)	
J2 (including J2 W, J2 N, J2 S in Bauder 1986 and City of San Diego 2004) (not including mitigation pools) (City of San Diego 2006)	Otay Mesa, City of San Diego, San Diego County	J2 N-Wall/Hudson Caltrans ; J2 S and W-Private and City of San Diego	partially developed, remainder conserved, restored (Service 1997b, 2004b, c)	nonnative plants, fragmentation	management	X (RECON 1997; Service 1998a; City of San Diego 2004)	F
J11E (City of San Diego 2004, 2006)	Otay Mesa, City of San Diego, San Diego County	Private	not preserved	development, OHV, nonnative plants, fragmentation	conservation, restoration, management	X+ (Service 1998a)	F
J11W (City of San Diego 2006)	Otay Mesa, City of San Diego, San Diego County	Private	not preserved	development, OHV, nonnative plants, fragmentation	conservation, restoration, management	X+ (Service 1998a; City of San Diego 2004)	F

Appendix 1. Vernal pool complexes identified as occupied at listing of San Diego fairy shrimp in 1997 (62 FR 4925) and since listing.

Complex Name	Location	Ownership	Status	Major Threats	Needs	Occupied	Recovery Plan Appendix
J13N (City of San Diego 2006)	Otay Mesa, City of San Diego, San Diego County	Private	proposed development	development, OHV, nonnative plants, fragmentation	conservation, restoration, management	X (Service 1998a; City of San Diego 2004)	F
J13S (City of San Diego 2004, 2006)	Otay Mesa, City of San Diego, San Diego County	Private	not preserved	development, OHV, nonnative plants, fragmentation	conservation, restoration, management	X (Service 1998a)	F
J14 (Anderson/SR 905) (City of San Diego 2006)	Otay Mesa, City of San Diego, San Diego County	Private	proposed development/conservation, SR 905 (Service 2004b)	development, OHV, nonnative plants, fragmentation	conservation, restoration, management	X+ (City of San Diego 2004; Helix 2006a)	F
J15 (Arnie's Point) (City of San Diego 2004, 2006)	Otay Mesa, City of San Diego, San Diego County	Department of Homeland Security	partially developed, remainder conserved, restored (Service 2002)	nonnative plants	management	X (Service 1998a; Helix 2005a)	F
J16-17 (Goat Mesa/Wruck Canyon) (City of San Diego 2004, 2006)	Otay Mesa, City of San Diego, San Diego County	City of San Diego	conserved	nonnative plants, OHV	restoration, management	X (Service 1998a)	F
J22 (Sunroad Centrum)	Otay Mesa, City of San Diego, San Diego County	Private	proposed development (Service 2003b)	development, OHV, nonnative plants, fragmentation	conservation, restoration, management	X+	
J25 (CNDDDB occurrence number 7)	Otay Mesa, City of San Diego, San Diego County	County of San Diego	not preserved	development, grazing, OHV, nonnative plants	conservation, management	X+ (CNDDDB 2008)	F
J26 (Upham)	Otay Mesa, City of San Diego, San Diego County	Private	partially restored, conserved pre-listing (Service 1996d)	development, nonnative plants, OHV, fire control	management	X+	F

Appendix 1. Vernal pool complexes identified as occupied at listing of San Diego fairy shrimp in 1997 (62 FR 4925) and since listing.

Complex Name	Location	Ownership	Status	Major Threats	Needs	Occupied	Recovery Plan Appendix
J28E (City of San Diego 2004, 2006)	Otay Mesa, City of San Diego, San Diego County	Private	proposed development	development, OHV, nonnative plants, fragmentation	conservation, restoration, management	X+ (Helix 2005b)	F
J29-30 (Lonestar/ McMillan/ New Millennium) (City of San Diego 2004, 2006)	Otay Mesa, City of San Diego, San Diego County	Otay Ranch	proposed development	development, OHV, nonnative plants, fragmentation	conservation, restoration, management	X (Service 1998a; Helix 2003b, 2006b)	F
J32++ (West Otay A+B) (mitigation site) (City of San Diego 2006)	Otay Mesa	The Environmental Trust	TET informal mitigation bank	OHV, nonnative plants	restoration, management	X+ (City of San Diego 2004)	
J3 (City of San Diego 2006)	Otay Mesa, City of San Diego, San Diego County	Private/Caltrans/ Sweetwater Union High School	partially developed, remainder not preserved, proposed development-State Route 905 (Service 2000c, 2004b)	development, OHV, nonnative plants, fragmentation	conservation, restoration, management	X+ (City of San Diego 2004; Helix 2002)	
J33++ Sweetwater High School	Otay Mesa, City of San Diego, San Diego County	Private/ Sweetwater Union High School	conserved; mitigation site (Service 2000c)	nonnative plants		X+	
J34++ (Candlelight) (City of San Diego 2004, 2006)	Otay Mesa, City of San Diego, San Diego County	Private	proposed development	development, OHV, nonnative plants, fragmentation	conservation, restoration, management	X+ (Helix 2004b, c)	
J2W++ (St. Jeromes Church/Clayton) (City of San Diego 2006)	Otay Mesa, City of San Diego, San Diego County	Private	proposed development	development, OHV, nonnative plants, fragmentation	conservation, restoration, management	X+ (Dudek and Associates 2001b)	

Appendix 1. Vernal pool complexes identified as occupied at listing of San Diego fairy shrimp in 1997 (62 FR 4925) and since listing.

Complex Name	Location	Ownership	Status	Major Threats	Needs	Occupied	Recovery Plan Appendix
S1-3	Sweetwater Reservoir, Unincorporated San Diego County	Sweetwater Authority/ Service	conserved, National Wildlife Refuge (Service 2003c)	nonnative plants, fire control	restoration, management	X+	
Tijuana Estuary (in Appendix G only)	Tijuana Slough	U.S. Fish and Wildlife Service	conserved pre-listing	nonnative plants	management	X+ (Service 1998a)	G
J35++ (Brown Field) (City of San Diego 2004, 2006)	Otay Mesa, City of San Diego, San Diego County	City of San Diego	not preserved (Service 1999b)	development, nonnative plant, emergency response, fragmentation	conservation, restoration, management	X+ (Helix 1998c)	
East Otay Mesa++ (Arnaiz Parcel, Area 2 Secondary Border Fence Project, SR-11 /Otay Crossings Commerce Park)	Otay Mesa, Unincorporated San Diego County	Caltrans/ Department of Health Services/ Private	partially developed, proposed development (Service 2003d)	development, OHV, nonnative plants, fragmentation	conservation, restoration, management	X+ (Recon 2001b; Helix 2005c; URS 2005)	
East Otay Mesa++ (CNDDDB occurrence number 57)	Otay Mesa, Unincorporated San Diego County	Private	not preserved	development, OHV, nonnative plants, fragmentation	conservation, restoration, management	X+ (CNDDDB 2008)	
East Otay Mesa Detention Facility near J26++	Otay Mesa, Unincorporated San Diego County	County of San Diego	partially developed (Service 1996d)			X+	
Antonio Parkway++	Unincorporated Orange County	County of Orange	developed (Service 1996a)			Xh	
J1 (Caltraces)	Otay Mesa, City of San Diego, San Diego County	Private	developed (Service 1997b)			Xh (Service 1998a)	

F = listed in Appendix F of Recovery Plan ["Recovery Plan Appendix" column]

G = listed in Appendix G of Recovery Plan ["Recovery Plan Appendix" column]

X+ = Complex documented as unoccupied in Recovery Plan or not listed in Plan; documented as occupied since Recovery Plan ["Occupied" column]

Xh = San Diego fairy shrimp extirpated from complex ["Occupied" column]

++ = complex/occurrence found since Recovery Plan ["Complex Name" column]

DOD MA 1 – 5 = Department of Defense Management Area designations: MA 1 receive the highest conservation priority; MA 5, the lowest (MCAS Miramar 2006)

Appendix 2. Unoccupied Vernal Pool Complexes Listed in Appendices F and G of the Recovery Plan (Service 1998a).

Complex Name	Location	Owner	Status	Major Threats	Needs 2007	Occupied	In Recovery Plan Appendix
El Toro	City of Irvine, Orange County	U.S. Navy (will be 100% non-military once environmental remediation efforts are complete)	partially impacted by remediation, subsequently enhanced in 2005, potential restoration site for Los Angeles Airport	nonnative plants	conservation, restoration, management	NP	F
Saddleback Meadows	Unincorporated Orange County	Private	proposed development	development, cattle	conservation, restoration, management	NP	F
San Clemente (San Clemente State Park in Appendix F)	San Clemente State Park	State	not preserved	development	conservation, restoration, management	NP	F
Orange County Foothills (undescribed) in Appendix F only	Unincorporated Orange County					NP	F
Hemet/ Salt Creek	Riverside	Private/Public				NP	F
Temecula	Riverside	?	?		?	NP	F
Santa Rosa Plateau	Riverside County	The Nature Conservancy	conserved			NP	F
Skunk Hollow (known at listing)	Riverside County	The Center for Natural Lands Management	conserved, managed	fragmentation, nonnative plants, edge effects		NP	F
H1-3 (Del Mar Mesa)	Del Mar Mesa	City of San Diego/ Service	conserved, mitigation, NWR	nonnative plants, OHV, fire control	restoration, management	NP	F
AA12	Miramar	U.S. Marine Corps	DOD MA 1	nonnative plants, fire control, military activities	conservation, restoration, management	NP	F
AA12 south	Miramar	U.S. Marine Corps	DOD MA 1	nonnative plants, fire control, military activities	conservation, restoration, management	NP	F

Appendix 2. Unoccupied Vernal Pool Complexes Listed in Appendices F and G of the Recovery Plan.

Complex Name	Location	Owner	Status	Major Threats	Needs 2007	Occupied	In Recovery Plan Appendix
AA2 (maybe included in Appendix F as AA 1-7; included in Bauder)	Miramar	U.S. Marine Corps	DOD MA 1	nonnative plants, fire control, military activities	conservation, restoration, management	NP	F
HH4+	Miramar	U.S. Marine Corps	DOD MA 1, impacted 90% filled	nonnative plants, fire control, military activities	conservation, restoration, management	NP	F
Highland Valley (Oak Country?)	Ramona	Private	not preserved	development	conservation, restoration, management	NP	F
Main Street	Ramona	Private	not preserved	development	conservation, restoration, management	NP	F
K3-4	Otay lakes	City of San Diego	not preserved		conservation, restoration, management	NP	F
K5	Otay lakes	City of San Diego	not preserved		conservation, restoration, management	NP	F
J12	Otay Mesa	Private	not preserved	development	conservation, restoration, management	NP	F
J13E	Otay Mesa	Private	not preserved	development	conservation, restoration, management	NP	F
J18 (Goat Mesa/Wruck Canyon)	Otay Mesa	City of SD	conserved	nonnative plants, Border Patrol activities	restoration, management	NP	F
J19	Otay Mesa	Private	agriculture	development, Border Patrol activities	conservation, restoration, management	NP	F
J20	Otay Mesa	Private	agriculture	development, Border Patrol activities	conservation, restoration, management	NP	F

Appendix 2. Unoccupied Vernal Pool Complexes Listed in Appendices F and G of the Recovery Plan.

Complex Name	Location	Owner	Status	Major Threats	Needs 2007	Occupied	In Recovery Plan Appendix
J21	Otay Mesa	Private - drainage issues	agriculture, border fence	development, Border Patrol activities	conservation, restoration, management	NP	F
J23-24	Otay Mesa	County of San Diego	not preserved	development	conservation, management	NP	F
J27	Otay Mesa	Private - Empire Center	partially impacted, partially restored, conserved	nonnative plants, fragmentation	conservation, restoration, management	NP	F
J28W	Otay Mesa	Private -	proposed development	development	conservation, restoration, management	NP	F
R1 - Proctor Valley	Proctor Valley	City of San Diego	not preserved		conservation, restoration, management	NP	F
R2+	Proctor Valley	Private	?		?	NP	F
R3+	Proctor Valley	Private	?		?	NP	F
R4+	Proctor Valley	Private	?		?	NP	F
Cruzan Mesa	Unincorporated Los Angeles County	Private	conserved – Santa Monica Mountains Conservancy	edge effects	continued monitoring	NP	F
Tejera Rejada Preserve (Carlsberg Complex in Recovery Plan)	City of Moorpark, Ventura County	Public – Mountains Recreation and Conservation Authority	conserved	nonnative plants, altered hydrology, fragmentation	continued monitoring, restoration, management	NP	F
Ellwood Mesa (Sterling Preserve)	Santa Barbara	Public – City of Goleta	conserved	nonnative plants, edge effects		NP	G
More Mesa	Santa Barbara	Public (County of Santa Barbara); and Private	?	development	native grasslands restoration (ongoing)	NP	G
H (undescribed) in Appendix G only	Del Mar Mesa	?	?	?		NP	G
I6b (Bob Baker)	Kearny Mesa	Private - City easement	mitigation		conservation, restoration, management	NP	G

Appendix 2. Unoccupied Vernal Pool Complexes Listed in Appendices F and G of the Recovery Plan.

Complex Name	Location	Owner	Status	Major Threats	Needs 2007	Occupied	In Recovery Plan Appendix
I6c (Bob Baker 2)	Kearny Mesa	Private - City easement	mitigation		conservation, restoration, management	NP	G
D1 (Fenton Mira Mesa Sandmine)	Mira Mesa	Private	impacted, filled			NP	G
'F28 (Appendix G only)	Miramar	U.S. Marine Corps	See complex F (north)			NP	G
L14+ Grand/Pacific	San Marcos	Private	proposed development	development	conservation, restoration, management	NP	G
L16+ Armolite South (Pacific Station)	San Marcos	Private	proposed development	development	conservation, management of remaining pools	NP	G
L17+ Pico/Mission	San Marcos	Private	not preserved	development	conservation, management of remaining pools	NP	G
L18+ Mission/Las Posa	San Marcos	Private	impacted			NP	G
L19+ Grand Ave	San Marcos	Private	proposed development	development	conservation, management of remaining pools	NP	G
L20+ Los Vallecitos	San Marcos	Private	impacted?			NP	G
L7-8	San Marcos	Private	impacted			NP	G
Basilone	Camp Pendleton	U.S. Marine Corps	DOD			NP	G
K1	Otay lakes	Private	not preserved	development	conservation, restoration, management	NP	G
K2 (in Appendix G only)	Otay lakes		not preserved	development	conservation, restoration, management	NP	G
K6	Otay lakes	Private	proposed development	development	conservation, restoration, management	NP	G

Appendix 2. Unoccupied Vernal Pool Complexes Listed in Appendices F and G of the Recovery Plan.

Complex Name	Location	Owner	Status	Major Threats	Needs 2007	Occupied	In Recovery Plan Appendix
K7	Otay lakes	Private	Not identified in City of San Diego 2004	development	conservation, restoration, management	NP	G
J (undescribed) in Appendix G only	Otay Mesa					NP	G
Isla Vista-Camino Corto	Santa Barbara	County of Santa Barbra	?		?	NP	G
Isla Vista-del Playa	Santa Barbara		?		?	NP	G
Isla Vista-Del Sol	City of Santa Barbara, Santa Barbara County	City of Santa Barbara	mitigation	nonnative plants	management	NP	G

F=listed in Appendix F of Recovery Plan

G=listed in Appendix G of Recovery Plan

++ = complex/occurrence found since Recovery Plan ["Complex Name" column]

NP = Complex not currently know to be occupied

DOD MA 1-5= Department of Defense Management Area designations: MA 1 receive the highest conservation priority; MA 5, the lowest (MCAS Miramar 2006)

**U.S. FISH AND WILDLIFE SERVICE
5-YEAR REVIEW**

San Diego fairy shrimp (*Branchinecta sandiegonensis*)

Current Classification: Endangered

Recommendation Resulting from the 5-Year Review:

- Downlist to Threatened
- Uplist to Endangered
- Delist
- No change needed

Review Conducted By: Ayoola Folarin, Carlsbad Fish and Wildlife Office, Carlsbad, California.

FIELD OFFICE APPROVAL:

Lead Field Supervisor, U.S. Fish and Wildlife Service

Approve  Date 9-23-2008

REGIONAL OFFICE APPROVAL:

Lead Assistant Regional Director, U.S. Fish and Wildlife Service, Region 8

Approve  Date 9/30/08