

Riverside Fairy Shrimp
(Streptocephalus woottoni)

**5-Year Review:
Summary and Evaluation**



Photograph: C. Brown, USGS

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

September 2008

5-YEAR REVIEW

Riverside Fairy Shrimp (*Streptocephalus woottoni*)

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 Riverside fairy shrimp is a small (0.56 - 0.92-inch (14 - 23-millimeter)) aquatic crustacean in the order Anostraca generally restricted to vernal pools and other non-vegetated ephemeral (i.e., lasting a short time) pools in (1) inland areas of Riverside County, Orange County, and the vicinity of Ramona, San Diego County; and (2) coastal areas of San Diego County and northwestern Baja California, Mexico.

Methodology Used to Complete This Review:

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

Contact Information:

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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 2 letters regarding this 5-year review. Relevant information provided by these letters has been included in the review.

Listing History:

Original Listing

FR Notice: 58 FR 41384

Date of Final Listing Rule: August 3, 1993

Entity Listed: Shrimp, Riverside fairy (*Streptocephalus woottoni*), an invertebrate species

Classification: endangered

The original listing rule also included three vernal pool plant species: *Pogogyne nudiuscula* (Otay Mesa Mint), *Orcuttia californica* (California Orcutt grass), and *Eryngium aristulatum* var. *parishii* (San Diego button celery).

Associated Rulemakings:

Original Final Critical Habitat

FR notice: 66 FR 29384

Date: May 30, 2001

Revised Proposed Critical Habitat

FR notice: 69 FR 23024

Date: April 27, 2004

Revised Final Critical Habitat

FR notice: 70 FR 19154

Date: April 12, 2005

Review History: No previous 5-year reviews have been completed for this species.

Species' Recovery Priority Number at Start of 5-Year Review: The recovery priority number for Riverside fairy shrimp is 5C 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 low potential for recovery. The “C” indicates conflict with construction or other development projects.

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 Riverside fairy shrimp (*Streptocephalus woottoni*) is a small aquatic crustacean in the order Anostraca, first identified in 1985 (Eng et al. 1990) based on specimens collected from between Murrieta Golf Course and California Highway 79 in Riverside County. Riverside fairy shrimp feed on algae, bacteria, protozoa, rotifers, and bits of detritus (Eng et al. 1990; Eriksen and Belk 1999). Male Riverside fairy shrimp are distinguished from other fairy shrimp species primarily by the second pair of antennae (Eriksen and Belk 1999). The females carry their cysts (i.e., eggs) in an oval or elongate ventral brood sac (Eriksen and Belk 1999).

Species Biology and Life History

Riverside fairy shrimp are generally restricted to vernal pools and other non-vegetated ephemeral (i.e., containing water a short time) pools greater than 12 inches (30.5 centimeters) in depth in Riverside, Orange, and San Diego counties in southern California, and northwestern Baja California, Mexico¹. Riverside fairy shrimp are usually observed from January to March. However, the hatching period may be extended in years with early or late rainfall. Individuals hatch, mature, and reproduce within 7 to 8 weeks of rainfall filling a pool, depending on water temperature (Hathaway and Simovich 1996; Simovich and Hathaway 1997).

The cysts from successful reproduction are either dropped to the pool bottom or remain in the brood sac until the female dies and sinks. The cysts are capable of withstanding temperature extremes and prolonged drying. Only a portion of the cysts may hatch when the pools refill in

¹ Vernal pool complexes are defined as a series of vernal pool groups that are hydrologically connected with similar species compositions (See “Habitat or Ecosystem” section of this review).

the same or subsequent rainy seasons; therefore, cyst “banks” develop in pool soils that are composed of the cysts from several years of breeding. This partial hatching of cysts allows the Riverside 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 2005, Simovich and Hathaway 1997). Riverside 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)). The ability of Riverside fairy shrimp to develop and maintain cyst banks is vital to the long-term survival of Riverside fairy shrimp populations (Ripley et al. 2004, Simovich 2005).

Spatial Distribution

The August 3, 1993, listing rule stated that Riverside fairy shrimp were known to inhabit 9 vernal pool complexes within Riverside, Orange, and San Diego counties, and Baja Mexico, including four vernal pools in Riverside County, one population in Orange County, two areas in San Diego County, and two locations in Baja California, Mexico (58 FR 41384). However, we now believe the type locality (Murrieta Golf Course) for this species was likely already lost to development prior to listing (Eriksen and Belk 1999). In addition, the one population in Orange County referenced in the listing rule has never been confirmed. Thus, at listing, it is likely that there were only three extant occurrences of Riverside fairy shrimp known from Riverside County, two occurrences known from San Diego County, and two occurrences known from Mexico (i.e., 5 in the United States and 2 in Mexico).

Since listing, as many as 52 additional occupied complexes have been identified, including one man-made complex at Johnson Ranch (see Table 1). Additionally, there is 1 complex (Banning) in which *Streptocephalus* species cysts have been found. Although these may be Riverside fairy shrimp cysts, it is more likely they are cysts of the common New Mexico fairy shrimp (*S. dorotheae*), which is known to occur in Banning less than 1 mile (1.6 kilometers) from this site (Eriksen and Belk 1999). Since listing, about 9 of the total 57 complexes are known to have been extirpated, and we are unsure whether the species persists in 3 other complexes; hence, there are currently 45 known occupied vernal pool complexes (approximately 200 occupied pools), which include the man-made complex at Johnson Ranch (see Figure 1, Table 1, and Appendix 1). More than half of all extant complexes known to contain Riverside fairy shrimp are in San Diego County, including 8 complexes on Marine Corps Base (MCB) Camp Pendleton. These 8 complexes are of particular interest as they support approximately 56 percent of all identified individual vernal pools known to be occupied by the Riverside fairy shrimp (RECON 2001b, 2007; MCB Camp Pendleton 2007). Approximately 24 percent of extant known occupied complexes are in Riverside County, and approximately 17 percent are in Orange County. We have no information on the current status of the two occurrences known in Mexico at the time of listing.

Figure 1. Distribution of Riverside fairy shrimp (from Service files, Carlsbad Fish and Wildlife Office, 2008).

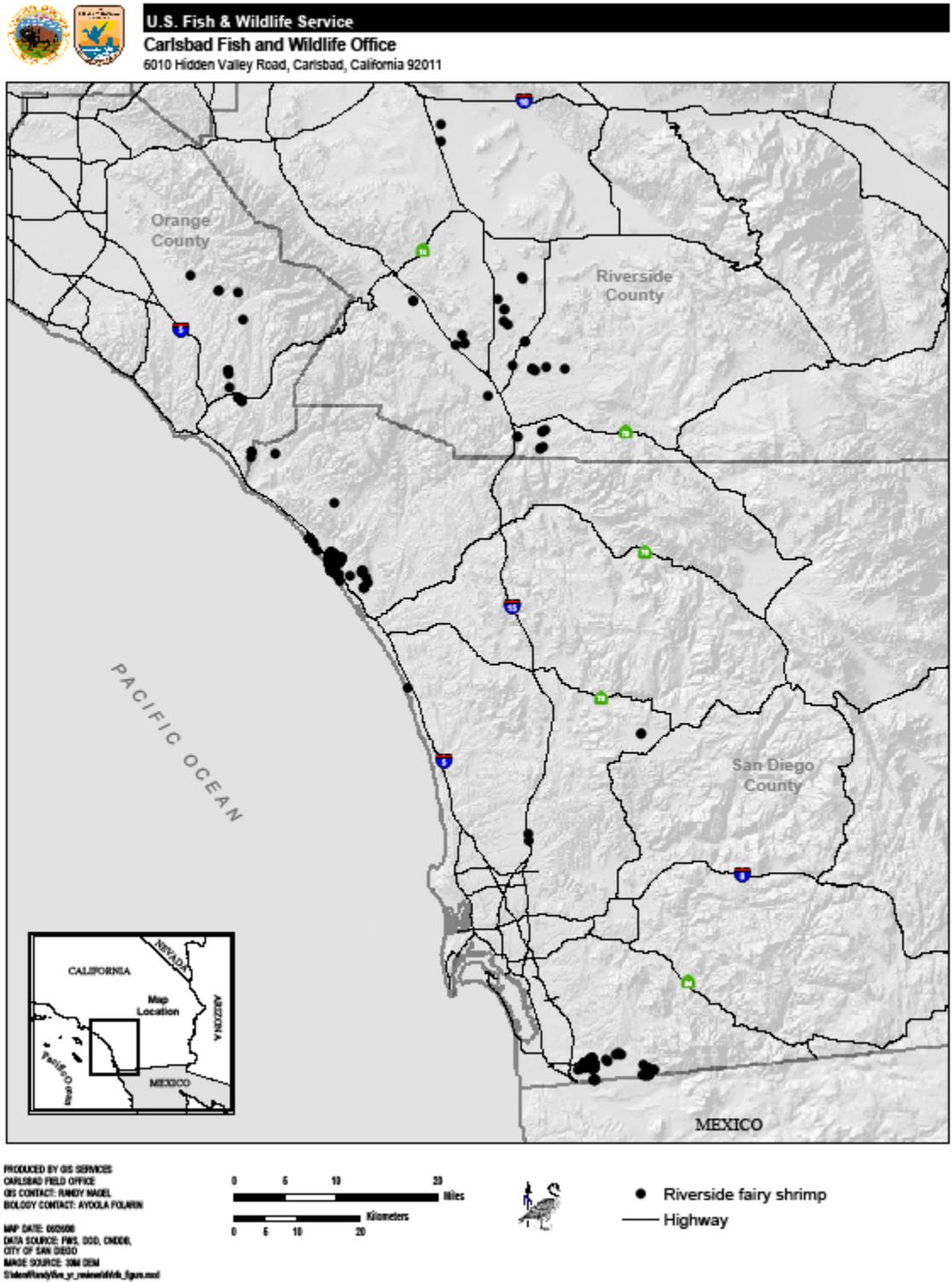


Table 1. Riverside fairy shrimp occurrences and area of occupied habitat (in acres (ac) and hectares (ha)) identified at listing in 1993 (58 FR 41384) and since listing (Service files, Carlsbad Fish and Wildlife Office, 2008).

Location	Complex	Currently Extant?
Ventura County	Tierra Rejada Preserve complex	unknown
Subtotal known extant complexes: 0		

Los Angeles County	LA Airport complex	no
Subtotal known extant complexes: 0	Madrona Marsh complex	unknown

Riverside County 42 ac (17 ha) extant [includes 2 ac (1 ha) man-made 38 ac (15 ha) conserved]	Skunk Hollow Pool*	yes	
	Field Pool*	yes	
	Pechanga Pool*	yes	
	Schau pools	yes	
	Johnson Ranch	yes	
	Australia Pool	yes	
	Schleuniger Pool	unknown	
	Subtotal known extant complexes: 11	March Air Reserve Base	cysts
		Scott Pool	cysts
		Rancho California Road	yes
		Rainbow Canyon Pool	yes
		Grizzle Ranch	no
		Garbani property	no
		Redhawk property	no
	French Valley Town Center	no	
	Clayton Ranch	no	

Riverside County (cont.)	Warm Springs property	Yes
	Temecula Education Complex	No

Orange County 4 ac (2 ha) extant [includes 2 ac (1 ha) conserved]	El Toro complex	Yes	
	Whiting Ranch complex	Yes	
	Live Oak Plaza complex	Yes	
	Subtotal known extant complexes: 8	Saddleback Meadows complex	Yes
		O'Neill Park/Clay Flats pond property complex	Yes
		Tijeras Creek complex	Yes
		Antonio Parkway complex	No
		Chiquita Ridge complex	Yes
		Radio Tower Road complex	Yes

Table 1 (continued).

Location	Complex	Currently Extant?
San Diego County 13 ac (5 ha) extant [includes 5 ac (2 ha) conserved]	AA1 east complex (Miramar)*	yes
	AA1 south complex (Miramar)	yes
	Ramona T complex	yes
	JJ2 complex	yes
	Subtotal known extant complexes: 26	
	Marine Corps Base Camp Pendleton	
	Cockleburrr Mesa	yes
	Las Pulgas complex	yes
	O'Neill complex	yes
	San Mateo complex	yes
	Stuart Mesa complex	yes
	Wire Mountain complex	yes
	Papa Three complex	yes
California State Park Lease Area complex	yes	

San Diego County (cont.)	Otay Mesa	
	J29-30 complex*	Yes
	J2	Yes
	J2W++	Yes
	J3	Yes
	J33++	Yes
	J4-7	Yes
	J14	Yes
	J14++ (Recon South)	Yes
	J15 (Arnie's Point)	Yes
	J22	Yes
	J32++	Yes
	J34	Yes
	J35++	Yes
	East Otay Mesa	Yes
	J1 Calterracas	No

Mexico	2 locations*	Unknown
Total known extant complexes: 45 Total known extant habitat: 59 ac (24 ha) Total conserved habitat: 45 ac (18 ha) (5 ac (2 ha) military) Total known extirpated complexes: 9 Total complexes unknown status: 3		
*Occurrence known at time of listing (5 in U.S.; 2 in Mexico).		

Most of the additional complexes identified since listing fall generally within the range of the Riverside fairy shrimp described in the listing rule, although the identification of some complexes broadened the specific range within Riverside, Orange, and San Diego counties. Three complexes were discovered post-listing within Ventura and Los Angeles counties. Of these three complexes, one has been extirpated in Los Angeles County and adult fairy shrimp have not been recently identified in the other two (see Table 1 and Appendix 1). Aside from the

one man-made complex at Johnson Ranch, we believe 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 Riverside fairy shrimp distribution and range into previously unoccupied areas. Rather, they provide a better understanding of the historical distribution and range of the Riverside fairy shrimp that was unknown at the time of listing. The current Riverside fairy shrimp distribution is shown in Figure 1 below. A summary of occupied vernal pool complexes known at listing and identified since listing is provided in Table 1 and Appendix 1; the Riverside fairy shrimp occurrences in 12 of these complexes have been extirpated or have not been confirmed since their discovery.

Adequately quantifying occurrence and distribution of the Riverside fairy shrimp is difficult due to a number of factors. First, vernal pools are generally too small to appear on topographic maps (Holland 1976) and therefore difficult to identify. Riverside fairy shrimp are restricted to certain pool types within a narrow geographic region and they emerge later in the season than other fairy shrimp species (Hathaway and Simovich 1996). Thus, once vernal pools are identified, surveys intended to document Riverside fairy shrimp and earlier-occurring species may actually miss the Riverside fairy shrimp as they may still be so small (i.e., juvenile stage) that they pass through the mesh of the collecting nets (Eriksen and Belk 1999). Second, not all vernal pools fill in a given year, and pools may not fill long enough for hatching (i.e., discovery) of the Riverside fairy shrimp. Some estimates for San Diego County indicate that over a period of 13 years, approximately only 28 percent of the pool-filling events lasted 17 days or longer (Philippi et. al. 2001). Riverside fairy shrimp can hatch within 7 to 12 days of inundation (Eriksen and Belk 1999; Hathaway and Simovich 1996), but they mature relatively slowly (taking 7 weeks to 2.5 months to reach maturity (Hathaway and Simovich 1996)), and may still be too small to be detected in 17 days. Third, in any given pool that has retained water long enough to hatch Riverside fairy shrimp, surveys may miss collecting adults simply due to the species' low hatching percent (i.e., as few as 0.18 percent; Simovich and Hathaway 1997). Finally, only males can be identified to the species level with certainty (Eriksen and Belk 1999), and cysts can only be identified to the genus level. All of these factors may result in detecting a seemingly low population level, or surveys may not detect individuals in a particular year even when adults and/or viable cysts are present.

Abundance

Surveying occurrences for changes in numbers of individuals and demographic trends over time is not possible due to the small size and life history traits of Riverside fairy shrimp. However, research into the development of population assessment methods being pursued for San Diego fairy shrimp will likely be applicable to Riverside fairy shrimp. Population trends are determined indirectly by assessing changes in the amount of habitat occupied by the species over time. Although there are more known occupied locations now than were known at the time of listing, we believe that, with the exception of the one man-made complex at Johnson Ranch, the additional occupied pools were likely in existence (though undocumented) when the species was listed. Additionally, most losses due to development since the species was listed have been, or will be, offset via vernal pool preservation (i.e., the physical and legal protection of existing vernal pool basins), 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/or enhancement (e.g., removal of trash, control of nonnative plants, introduction of Riverside fairy shrimp into man-made or restored pools where appropriate, etc.) of Riverside fairy shrimp habitat through consultations under section 7 and section 10 of the Act. Therefore, we estimate that Riverside fairy shrimp abundance has not increased or decreased substantially since listing.

Habitat or Ecosystem

Riverside fairy shrimp generally occur in groups of vernal pools referred to as vernal pool complexes (Keeler-Wolf et al. 1998). As described in the “Spatial Distribution” section above, there are 45 vernal pool complexes known to be occupied by the Riverside fairy shrimp in Riverside, Orange, and San Diego counties. A Service analysis of occupied vernal pools indicated that this species is restricted to approximately 59 acres (ac) (24 hectares (ha)) of remaining habitat (Service files, Carlsbad Fish and Wildlife Office, 2008). Although the greatest number of individual occupied pools and complexes occur in San Diego County, one pool in Riverside County, Skunk Hollow, is 33 ac (13 ha) in size, and therefore the greatest extent of occupied habitat occurs in Riverside County (Appendix 1).

Vernal pool complexes tend to average between 5 and 50 vernal pools, although some contain as few as two vernal pools and others contain several hundred vernal pools (complexes containing Riverside fairy shrimp often contain only 1 or 2 pools; however, on MCB Camp Pendleton and Otay Mesa in San Diego County, complexes generally contain many 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 (Riverside fairy shrimp habitat acreages provided in this review do not include pool watersheds). 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). Riverside 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, 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

No research on Riverside fairy shrimp genetics has been conducted to date. However, a recent mitochondrial DNA (i.e., genetic sequence of maternally-inherited DNA located outside the cell nucleus) study was completed for the San Diego fairy shrimp (*Branchinecta sandiegonensis*), whose range overlaps with the Riverside fairy shrimp in San Diego and Orange counties. The San Diego fairy shrimp study concluded that individuals of that species have likely been isolated from one another biologically for tens of thousands or perhaps millions of years with little or no dispersal or hybridization (Bohonak 2005). Bohonak (2005) found that 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. Furthermore, Bohonak's results indicate that gene flow between pool complexes is lower in areas that have less disturbance from urbanization and human activities. The implications of genetic analyses are important when considering restoration or creating habitat and/or introducing a species into historically occupied habitat. It is not clear whether a genetic analysis of Riverside fairy shrimp would yield similar results, since fewer pools are occupied by Riverside fairy shrimp, and these pools are generally more spread out over its range.

Species-specific Research and/or Grant-supported Activities

A project was funded by a Service/U.S. Geological Survey Science Support Partnership Grant in 2007 to determine the effects of mosquito vector-control agents (*Bacillus thuringiensis* and *Bacillus sphaericus* (naturally occurring soil bacteria that act as larvicides for the control of mosquitoes and blackflies) and methoprene (a common pesticide)) on Riverside fairy shrimp and vernal pool fairy shrimp (*Branchinecta lynchi*). This project should be completed in December of 2009.

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 45 known extant complexes were likely occupied at the time of listing, the listing rule analyzed threats in the context of only 9 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 1993, the Riverside fairy shrimp was imperiled because the habitat on which the species is dependent, vernal pools, and the species' overall range had been greatly reduced (58 FR 41384). By that time, vernal pool habitat in San Diego County had declined by an estimated 97 percent (T. Oberbauer, Department of Planning and Land Use, San Diego County, pers. comm., 1990), and in Orange County, by an estimated 90 to 98 percent of the historical vernal pool habitat has been eliminated (F. Roberts, Service, pers. comm., 1993). Similar declines in habitat are believed to have occurred in Riverside and Ventura Counties, and to a lesser degree in Baja California, Mexico, and all pools in Los Angeles County were believed to have been lost (58 FR 41384). At the time the listing rule was written, we were only aware of 5 vernal pool complexes within the U.S. and 2 complexes in Mexico that were known to be occupied by the Riverside fairy shrimp. All of these areas were considered to be under imminent threat of development or other impacts and very little of all remaining vernal pool habitat was protected from ongoing development pressures. The listing rule states that remaining vernal pools were vulnerable to one or more of the following habitat disturbances: urban, road, and agricultural development; off-road vehicle (OHV) use; trash dumping; cattle trampling; human trampling; military activities; water management activities; and habitat isolation. We estimate that approximately 59 ac (24 ha) of habitat remains occupied by the Riverside fairy shrimp today at 45 separate complexes (Table 1 and Appendix 1). 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 a significant threat to Riverside fairy shrimp habitat across its range. The growth rate of the human population and associated urban and road development in southern California and northwestern Baja California is equal to or exceeds that of any other region in California. 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 (3,098,269; SANDAG 2007). The adjacent counties of Riverside and Orange are expected to grow by 23 and 8 percent, respectively, between 2010 and 2020 (California Department of Finance 2004). This predicted growth rate suggests that urban and road development pressures will continue to rise within the extant range of the Riverside fairy shrimp. In addition, development of border security and associated infrastructure also threatens the Riverside fairy shrimp along the international border. Such development can result in direct impacts to Riverside 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 Riverside fairy shrimp occupying the developed habitat. Since listing, Service files show that at least 9 complexes known to be occupied by the Riverside fairy shrimp at or since its listing have been lost to development, another 10 complexes have been partially lost to development, and 8 contain pools that have been impacted (damaged, but not lost) (Appendix 1). Therefore, more than half of all known complexes have been impacted by development, international border security, and military-related development since this species was listed in 1993 (Appendix 1). We expect additional impacts to 10 complexes occupied by Riverside fairy shrimp based on project analyses in completed section 7 consultations; however, we expect that the effect of these future impacts to the Riverside fairy shrimp will be minimized through the conservation measures, and terms and conditions, of our biological opinions and incidental take statements.

The magnitude of the threat of development has been lessened by the listing of the Riverside 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 Riverside fairy shrimp habitat are typically minimized through preservation, restoration, and/or enhancement of existing pools. While Service files show that about 7 ac (3 ha) of habitat have been lost to development, approximately 8 ac (3 ha) of occupied habitat have been restored and approximately 42 ac (18 ha) (including most restored habitat) have been conserved to minimize habitat losses and impacts. 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 Riverside 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 Riverside fairy shrimp, duration of ponding, water quality, etc.), 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, etc.) 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.

It is important to note that the restoration/enhancement of vernal pool habitat for the Riverside fairy shrimp may not immediately mediate the anticipated take. For example, the Service is aware of 3 complexes for which efforts to offset impacts to pools have not met criteria for success thus far: 2 man-made vernal pool projects (Johnson Ranch and Clayton Ranch) and 1 enhancement project (Chiquita Ridge). However, Service biologists work actively with project proponents to remedy issues that have arisen with these and other vernal pool restoration projects. Moreover, based on Service file

information, we consider most vernal pool restoration projects to successfully support the species so far.

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, Riverside 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 of listed species 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. Information in Service files indicates that approximately 2 ac (1 ha) of unauthorized losses at March Air Reserve Base, French Valley Towne Center, and Scott in Riverside County, and the Wire Mountain complex on MCB Camp Pendleton, as well as unauthorized damage to the Ramona T, Schau, and Schleuniger complexes. Impacts at French Valley Towne Center, Wire Mountain complex, and Ramona T complex have been since offset through contributions to a vernal pool conservation fund and/or restoration efforts. Compensation for the impacts at March Air Reserve Base, Schau, Schleuniger, and Scott complexes has not yet been addressed. Therefore, although impacts to Riverside fairy shrimp habitat are generally offset through preservation, restoration, and/or enhancement of suitable habitat, development projects continue to cause occasional unauthorized impacts to vernal pool habitat that may not be remediated.

Furthermore, remediation efforts may not be implemented in a timely manner. For example, Service files contain several instances in which remediation for past impacts has yet to happen. For example, funds collected as mitigation for development impacts to Riverside fairy shrimp habitat authorized under the Western Riverside Multi-Species HCP have yet to be used to purchase, restore, and/or manage Riverside fairy shrimp habitat. Offsetting measures for other authorized impacts (e.g., improvements to Los Angeles Airport) have not yet been implemented, and in a few cases no attempt has yet been made to offset unintentional or other unauthorized impacts.

In total, approximately 17 of the 45 known occupied complexes, or about 38 percent, occur on private lands that are not preserved and are thus vulnerable to future development. These privately-owned lands total approximately 7 ac (3 ha) in size and support 12 percent of all known remaining extant habitat. We expect impacts to 10 of these complexes in the near future based on project analyses in completed section 7 consultations. As the human population within the range of the Riverside fairy shrimp continues to grow, we expect the pressure to convert this species' habitat to development will increase. Although additional impacts to Riverside fairy shrimp habitat will be minimized via avoidance and minimization measures, this endemic species is restricted to approximately 59 ac (24 ha) and therefore remains vulnerable to impacts from development.

Habitat Isolation and Fragmentation

The listing rule identified habitat isolation as a significant threat to due to the possibility of stochastic events extirpating populations that then could not be recolonized by dispersal from nearby populations. Habitat fragmentation within complexes or groups of nearby complexes can isolate pools/complexes from upland habitats, which provide much of the Riverside fairy shrimp's food sources (algae, diatoms, and particulate organic matter brought into pools via overland flow of rainwater). 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. 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 threaten the species throughout its range.

Water Management/Altered Hydrology

While the final listing rule mentions water management as a threat, it does not provide further information on this threat. However, the final rule does discuss the threat of altering the hydrology of vernal pools. Development within a vernal pool watershed can alter the timing, temperature, frequency, and length of inundation of nearby vernal pools. As described in the "Habitat or Ecosystem" section above, persistence of Riverside 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 Riverside fairy shrimp habitat and thus threaten Riverside 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 Riverside 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 Riverside fairy shrimp. For example, a housing development authorized by a section 7 biological opinion partially impacted the watershed of the Tierra Rejada (Carlsberg) pool. Required wet season surveys conducted each year between 2002 and 2006 failed to locate any Riverside fairy shrimp adults at this site following the hydrological impacts (Mountains Recreation and Conservation Authority 2006).

Altered hydrology continues to threaten this species throughout its range. The Service recognizes this threat when consulting under section 7 or working with section 10 applicants on projects within vernal pool watersheds, and often works with developers to recommend measures to reduce this threat. For example, the Service recommends incorporating the use of Best Management Practices during project construction to reduce the amount of runoff and minimize water draining off impervious surfaces into vernal pool watersheds. However, even with minimization measures drainage and runoff issues have been observed. For example, 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 (near the JJ2 complex near Poinsettia Train Station in Carlsbad) failed, causing vernal pools in the mitigation area to be inundated with sediment-laden runoff in early 2008 (Marci Koski, Biologist, Service, pers. obs., 2008). Preserved pools should be monitored to determine if and where these impacts might be occurring, and identified impacts need to be addressed to prevent and reverse, where feasible, further damage to hydrological systems.

Nonnative Plants

Invasion of Riverside fairy shrimp habitat by nonnative plant species was identified as a threat to fairy shrimp habitat in the listing rule. Vernal pools have 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 rabbitsfoot 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 Riverside 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 the increased water uptake by a 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 Riverside fairy shrimp habitat needs to include measures to address nonnative vegetation control.

Agriculture

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

Grazing

Livestock grazing was identified in the listing rule as a threat to Riverside fairy shrimp. Limited grazing activities still occur within the range of the Riverside 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

The listing rule identifies military activities as a potential threat to vernal pools, but does not discuss how this threat specifically impacts Riverside fairy shrimp. At the time of listing, only one vernal pool containing Riverside fairy shrimp had been identified on military lands (Marine Corps Air Station (MCAS) Miramar). Currently, 12 vernal pool complexes occupied by Riverside fairy shrimp (27 percent of all known occupied complexes; approximately 56 percent of all known occupied pools) occur on military lands (Appendix 1).

- MCAS Miramar: 3 pools (2 complexes)
- March Air Reserve Base: 1 pool (1 complex)

- Former MCAS El Toro (U.S. Navy): 1 pool (1 complex identified as El Toro complex in Table 1)
- MCB Camp Pendleton: 8 “complexes” (18 percent of all complexes occupied by Riverside fairy shrimp range-wide) with a total of 111 pools (56 percent of all known occupied pools range-wide). The groupings of vernal pools referred to as “complexes” on MCB Camp Pendleton in this review correspond to the “vernal pool habitat areas” defined by RECON (2001b) and may not meet the definition of complexes used in this review. Many of the vernal pool habitat areas defined by RECON (2001b) contain multiple complexes; however, the RECON (2001b) vernal pool groupings comprise the only dataset that identifies occupancy by Riverside fairy shrimp and thus are used here. A result of this discrepancy is that the percent of total occupied complexes reported here for MCB Camp Pendleton (18 percent of all range-wide complexes occupied by Riverside fairy shrimp) does not accurately reflect the proportion of occupied habitat on the Base. For this reason, we have also reported the percent of total known occupied pools found on Base (56 percent of all occupied pools range-wide). It should also be noted that of the 2,403 vernal pools identified to date on Base, only 1,448 (approximately 60 percent) have been adequately surveyed for fairy shrimp (RECON 2007); therefore, it is likely that the estimated number of pools occupied by Riverside fairy shrimp on the Base is conservative (i.e., many unsurveyed pools may contain the species), but they are likely to be found within the same general areas (Service 2008).

Military maneuvers, the construction of military facilities, nonnative plants, and other threats discussed below under “Factor E”, threaten Riverside 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 Riverside 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 Riverside fairy shrimp pursuant to section 7 consultations and implementation of Integrated Natural Resources Management Plans (INRMP). Below we discuss threats to and management of Riverside fairy shrimp habitat at each military facility.

MCB Camp Pendleton supports approximately 56 percent of all known occupied Riverside fairy shrimp pools range-wide. Camp Pendleton completed an INRMP that includes measures to conserve the Riverside fairy shrimp and its habitat, and therefore provides a benefit to this species (MCB Camp Pendleton 2007). 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 Riverside fairy shrimp occurrences on Camp Pendleton (Service 2000c).

Since the listing of the Riverside fairy shrimp, up to 8 pools assumed or known to be occupied by Riverside fairy shrimp have been impacted or degraded in association with housing or infrastructure construction projects on MCB Camp Pendleton. Biological opinions for the various phases of testing for the Advanced Amphibious Assault Vehicle / Expeditionary Fighting Vehicle (Service 2000c, 2003c, 2004d) concluded that an unquantifiable number of Riverside fairy shrimp are anticipated to be harmed, and Riverside fairy shrimp may be extirpated from up to 17 of the 111 onsite pools. 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. Additionally, although impacts to occupied Riverside fairy shrimp habitat are generally avoided during routine maintenance of firebreaks and mowed fuelbreaks, four occupied pools were filled and disced near the Wire Mountain housing area in 1998 and 1999 during firebreak maintenance activities (U.S. Marine Corps 1998, 1999). The Marine Corps has since implemented restoration efforts in this area to offset these unauthorized impacts (RECON 2004). The Marine Corps is now in formal consultation with the Service to programmatically evaluate and address ongoing and future impacts to Riverside 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 Riverside 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 by 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 2005e). 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 Riverside fairy shrimp.

MCAS Miramar has an INRMP which covers Riverside fairy shrimp (MCAS Miramar 2006). The 2 vernal pool complexes on MCAS Miramar known to contain Riverside fairy shrimp are the AA1 south complex and the AA1 east complex, which are located in Level I Management Areas and receive the highest conservation priority at the facility. MCAS Miramar conservation measures for this species are further described in the “Factor D” discussion below.

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 Riverside fairy shrimp and its habitat on MCAS Miramar.

March Air Reserve Base has a draft INRMP that does not explicitly provide for conservation of Riverside fairy shrimp habitat (March Air Reserve Base 2005). Although cysts have been located onsite, the draft INRMP does not provide management for Riverside fairy shrimp as adult shrimp have not been located onsite. Previously this Base supported two occupied pools; however, one occupied pool was lost without authorization or mitigation by construction of an Air National Guard training facility (Service 2007b). The remaining pool is intact and cysts have been reported there, but it is not managed for Riverside fairy shrimp.

Former MCAS El Toro does not have an INRMP as the Department of Defense is closing this facility. However, remediation of groundwater contamination on the portion where one occupied pool occurs is pending while ownership is being transferred; it is not yet known who will take on ownership.

Conservation Measures Implemented Since Listing

Currently, approximately 42 ac (17 ha) of occupied habitat has been conserved to offset losses and impacts. Conservation of these lands captures, in part, approximately 36 percent (16) of known occupied complexes. An additional 27 percent of known occupied complexes occur on approximately 5 ac (2 ha) of military land where they are generally provided some protection under INRMPs and/or section 7 of the Endangered Species Act as described above. 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 (30.5-meter) 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 Riverside fairy shrimp, especially in areas where urbanization is expected to expand. Of the estimated 45 vernal pool complexes currently known to be occupied, Service files show that approximately 27 percent are on military land where they are managed for conservation under INRMPS or protected by other means, and approximately 36 percent are at least partially conserved on other lands. At least 9 complexes known to be occupied by the Riverside fairy shrimp at or since its listing have been lost to development and the status of many more is uncertain but likely extirpated (Table 1, Appendix 1). Of the estimated 45 occupied vernal pool complexes, 10 complexes have been partially lost to development (approximately 7 ac (3 ha) of habitat lost), and 8 additional complexes contain pools that have been impacted (damaged, but not lost) (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 and degradation continues, particularly on private lands. Restoration activities and associated conservation measures for Riverside fairy shrimp habitat have been implemented and improved over time; approximately 8 ac (3 ha) of habitat have been restored or enhanced since listing. However, these restoration measures have oftentimes been deficient or inadequately carried out. Additionally, even preserved lands are often subject to invasion by nonnative plants and other impacts described under Factor E that lower the quality of habitat for Riverside 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 1993 final listing rule (58 FR 41384). It was thought, however, that impacts due to unrestricted collecting for scientific purposes or excessive visits by individuals interested in seeing rare species could potentially result from the increased publicity associated with listing under the Act. 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 Riverside 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 Riverside 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 Riverside fairy shrimp. However, in vernal pools located near perennial water bodies, nonnative bullfrogs (*Rana catesbeiana*) (Service 1998a) or African clawed frogs (*Xenopus laevis*) (Susan Wynn, Biologist, Service, pers. obs., 2007) may prey on Riverside fairy shrimp. Predation by these nonnative species is not considered a major threat to the Riverside 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. 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 Riverside fairy shrimp. For activities undertaken, authorized, or funded by Federal agencies, NEPA requires the project be analyzed for potential impacts to the human environment prior to implementation (42 U.S.C. 4371 et seq.). 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 of significant impacts, it does not require that such impacts be mitigated. Additionally, NEPA is only required for projects with a Federal nexus. Therefore, actions taken by private landowners are not required to comply with this law.

Clean Water Act

Until recently, the Corps regularly took jurisdiction over vernal pools. In addition, at the time of listing the U.S. Army Corps of Engineers (Corps) Los Angeles District (LAD) generally took jurisdiction over all Riverside fairy shrimp habitat, regardless of whether it consisted of “road pools” or other unvegetated pools that were found within historic 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, the Corps has made determinations regarding regulation of 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 that are 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 Riverside fairy shrimp or other vernal pool fauna. In light of these rulings and changes in practice since listing, the LAD continued regulation of wetlands that contain Riverside fairy shrimp habitat is, at best, uncertain. Should Corps regulation of wetlands that contain Riverside fairy shrimp habitat be discontinued, unmitigated destruction of Riverside 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 Riverside 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 Riverside 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. 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. To date, only “no jeopardy” opinions have been issued for Riverside fairy shrimp. 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 enhancement of vernal pool habitat, through section 7 consultations.

Since its listing, the Service has issued 24 biological opinions under section 7 and 4 approvals under section 10 of the Act for the Riverside fairy shrimp. Impacts to approximately 5 ac (2 ha) of Riverside fairy shrimp habitat, and other unquantified impacts (e.g., from military training on MCB Camp Pendleton), have occurred from projects covered by these consultations and approvals. In addition, four other proposed developments that have been authorized through section 7 biological opinions are expected to impact a total of approximately 3.5 ac (1.4 ha), or about 6 percent of the total 59 ac (24 ha) of occupied Riverside fairy shrimp habitat range-wide. 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 Riverside 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 Riverside fairy shrimp is a “covered species” under most existing and planned individual and regional HCPs in southern California, including those in Riverside, San Diego, and Orange counties, which cover

most of the species' current range. As a covered species, the Riverside fairy shrimp may be afforded an additional layer of regulatory protection, even if the species were to be delisted. The three most important regional HCPs for the Riverside fairy shrimp are the Western Riverside County Multiple Species Habitat Conservation Plan (MSHCP) (approved by the Service in 2004), the Orange County Southern Subregion Habitat Conservation Plan (Southern Subregion HCP) (approved by the Service in 2007), and the City of San Diego Multiple Species Conservation Program/Natural Community Conservation Program/HCP (MSCP/NCCP/HCP; City of San Diego 1997) (approved by the Service in 1997).

Western Riverside County MSHCP

The Western Riverside County MSHCP is a large-scale, multi-jurisdictional HCP that addresses 146 listed and unlisted "Covered Species," including the Riverside fairy shrimp, within a 1,260,000-ac (509,900-ha) plan area in western Riverside County. The Western Riverside County MSHCP plan area includes 42,349 ac (17,100 ha) of modeled habitat with the potential to harbor vernal pools and associated species, including the Riverside fairy shrimp. Acres of "modeled habitat" for each individual species within the MSHCP Plan Area is based on our understanding of an individual species' requirements in the context of our master geographic information system (GIS) database (e.g., vegetation communities and/or elevation, soils, bioregions, historical and recent species occurrence distribution). However, other than the occurrences mentioned previously, the extent to which the Riverside fairy shrimp occurs in these habitats is not known (Service files, Carlsbad Fish and Wildlife Office). In the biological opinion for the Western Riverside County MSHCP, we concluded that up to 25,832 ac (10,500 ha) (61 percent) of the modeled habitat would be impacted and that the MSHCP Conservation Area would encompass the remaining 16,517 ac (6,680 ha) (39 percent) of modeled habitat for vernal pool species such as Riverside fairy shrimp, including 7,686 ac (3,110 ha) of new conservation (Additional Reserve Lands) and 8,831 ac (3,570 ha) of existing Public-Quasi Public Lands. Although the modeling effort identified up to 25,832 ac (10,500 ha) of habitat that could potentially support vernal pools, at the time of permit issuance we were aware of 18 complexes on 46 ac (19 ha) within the permitted boundary of the MSHCP.

The MSHCP contains avoidance, minimization, and mitigation measures that are expected to reduce the impacts to this species. Specifically, the MSHCP's Riparian/Riverine Areas and Vernal Pools Policy requires that habitat for this species be mapped throughout the Plan Area and avoided if feasible. If avoidance is not feasible, the plan requires surveys for Riverside fairy shrimp and conservation and management of 90 percent of occupied areas determined to have long-term conservation value for the species. Consequently, the loss of 10 percent of the occupied Riverside fairy shrimp habitats determined to have long-term conservation value for the species is expected under the plan, and despite the overall conservation requirement for this species, loss of occupied habitat is authorized under the plan. For example, while the Temecula Education Complex pool was occupied, its small size, location, and disturbance level led to a determination that this area did not have long-term conservation value to the species; alternate mitigation deemed to be biologically equivalent or superior to avoidance of this

pool was approved to offset its loss. Other occupied vernal pools have been lost to development authorized under the MSHCP, including two pools at Grizzle Ranch and one pool at Garbani.

Finally, the MSHCP includes species-specific objectives for the Riverside fairy shrimp with a conservation goal of including five Core Areas of occupied vernal pool and associated watershed habitat encompassing 11,942 ac (4,833 ha) within the MSHCP Conservation Area. These five Core Areas include the 33-ac (13-ha) Skunk Hollow pool within the Barry Jones Wetland Mitigation Bank. To date, one additional occupied pool has been conserved (Rancho California Road pool) and conservation of the Schleuniger pool and watershed is underway.

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 Riverside 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 ac (34,834 ha) (Service 2007c) of land in southern Orange County and, over its 75-year permit term, will establish an approximately 32,818-ac (13,281-ha) Habitat Reserve. The Habitat Reserve will consist of 11,950 ac (4,836 ha) of County-owned lands within the O'Neill Regional Park, Riley Wilderness Park, and Caspers Wilderness Park, and approximately 20,868 ac (8,445 ha) of land owned by Ranch Mission Viejo.

All vernal pools supporting Riverside 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 Riverside fairy shrimp will focus on maintaining the existing vernal pools and Riverside 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 2006).

Regular monitoring of the Chiquita Ridge and Radio Tower Road vernal pools will track the status of the Riverside 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 2006). 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 2006).

San Diego MSCP Subarea Plan under the San Diego County MSCP

In southwestern San Diego County, the MSCP planning area encompasses more than 582,000 ac (235,527 ha) 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 ac (69,201 ha) of preserve areas to provide conservation benefits for 85 federally listed and sensitive species, including the Riverside 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 Riverside fairy shrimp and its habitat to the maximum extent practicable, mitigation for impacts deemed unavoidable, and management to protect habitat against edge effects to Riverside fairy shrimp.

There are 14 known occupied complexes on approximately 8 ac (3 ha) within the permitted boundary of the MHCP. Approximately 5 ac (2 ha) of this habitat has been conserved under the MSCP (City of San Diego 2004). The City's subarea plan does not lay out specific, quantified goals for Riverside 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 occupied 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 5 of the known occupied complexes according to Service files (11 percent)). According to Service files these sites are in need of management to address threats. 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 of San Diego's MSCP/NCCP/HCP (approved by the Service in 1997) requires avoidance of impacts to the Riverside fairy shrimp and its habitat to the maximum extent practicable. The City's section 10(a)(1)(B) permit limits take authorization for this species to areas outside of jurisdictional waters of the U.S. as that term was understood prior to the Supreme Court's decision in *SWANCC*. As discussed above under "Clean Water Act," prior to *SWANCC* and at the time the City's permit was issued, the Corps LAD generally took jurisdiction over all Riverside fairy shrimp habitat, including "road pools" or other unvegetated pools that were found within historic vernal pool habitat. Because of this, the Service anticipated individualized review of projects impacting Riverside 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 CWA jurisdiction over vernal pools uncertain. In addition, 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 Riverside fairy shrimp and six other vernal pool species. The court held that the City's subarea plan does not provide adequate protection for the Riverside 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 Riverside 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 Riverside fairy shrimp, to the maximum extent practicable, and to monitor and manage vernal pools remains in place notwithstanding the Federal injunction.

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 Riverside fairy shrimp listing, it was not until 1997 when the Sikes Act Improvement Act was enacted that Department of Defense installations were required to prepare Integrated Natural Resource Management Plans (INRMPs). INRMPs provide 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 the priority for individual actions. Actions for federally listed species are generally given high priority. Implementation of an INRMP does not preserve any military lands in perpetuity as ultimately those lands may be necessary for National Security. While the INRMPs established under the Sikes Act are expected to provide conservation benefits to the Riverside fairy shrimp as long as it is listed, they are dependant on funding and do not commit to conserving habitat in perpetuity. Several INRMPs have been adopted since the listing of the Riverside fairy shrimp. The most important for the Riverside fairy shrimp are the INRMPs for MCAS Miramar and MCB Camp Pendleton.

On MCAS Miramar, vernal pool conservation and management at 2 complexes with Riverside fairy shrimp is guided by Miramar's INRMP, initially developed in 2000 and updated in 2006 (MCAS Miramar 2006). Miramar's strategy for conservation and management of Riverside

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 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 species, including Riverside fairy shrimp on 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 Riverside fairy shrimp management and conservation. Pending completion of this consultation, the Marine Corps has incorporated interim Riverside fairy shrimp management and conservation measures within 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). 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, changes in the project, or has the option to decide that mitigation

is unfeasible due to overriding considerations. Thus, while the Riverside 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. 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 Riverside fairy shrimp habitat, automatic waivers of discharge requirements are granted if the Regional Boards do not respond to applications within 120 days. This occurred for the proposed Ramona Unified School District project (ESA Log No. 4854) which proposes impacts to Riverside 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 Riverside fairy shrimp is found in vernal pools that are often not located in coastal sage scrub. However, the Riverside fairy shrimp has been treated as a covered species under the several regional NCCPs. The most significant NCCP plan to the Riverside fairy shrimp is the Western Riverside County MSHCP, 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 Riverside 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, nor has the City ordinance has not recognized many threats associated with development (i.e., habitat isolation and fragmentation, indirect effects of adjacent development, alternation of hydrology). The City of San Diego continues to approve projects that indirectly impact vernal pools by substantially or completely surrounding them with development, and directly impact road pools occupied by the Riverside fairy shrimp. Therefore, local regulations do not adequately protect the Riverside fairy shrimp and its habitat.

United Mexican States Law

The Service is not aware of any existing regulatory mechanisms that would protect the Riverside 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 most regulatory protection to the Riverside 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 Riverside fairy shrimp. Because of this, other Federal, State, and local laws and ordinances do not independently or collectively provide adequate regulatory protection to the Riverside 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 Riverside 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 trash dumping, human encroachment, increased runoff from impervious surfaces, and water pollution as threats to the species. 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

The listing rule identified habitat isolation as a significant threat to due to the possibility of stochastic events extirpating populations that then could not be recolonized by dispersal from nearby populations. On a regional scale, fairy shrimp habitat (vernal pools) is naturally fragmented (Bohonak 2005). How and to what degree dispersal of Riverside fairy shrimp occurs is unknown at this time. Since listing, genetic analyses of the San Diego fairy shrimp have shown that species to have high genetic divergence among vernal pool complexes, which implies that little genetic mixing occurs among complexes naturally (Bohonak 2005). A similar situation may be representative of Riverside fairy shrimp, because Riverside fairy shrimp and San Diego fairy shrimp are similar species with similar life histories, and which largely occupy the same habitat type (ephemeral pools) and similar range (although the range of Riverside fairy shrimp extends into Riverside County). Additionally, Riverside fairy shrimp occupy fewer complexes (45) than San Diego fairy shrimp (137), thus its occurrences are more spread out and fragmented than those of San Diego fairy shrimp, which further strengthens the likelihood that Riverside fairy shrimp is under the same selective pressures as San Diego fairy shrimp and may exhibit similar genetic patterns. The mixing that does occur could happen via a combination any of a number of potential mechanisms, including infrequent large-scale flooding events, dispersal of cysts by animals (e.g., waterfowl), wind dispersal of cysts in desiccated soils, etc. It is presumed that extirpated occurrences of Riverside fairy shrimp could be re-established through these dispersal mechanisms in the absence of habitat fragmentation. Due to the lack of information regarding the genetic composition of Riverside fairy shrimp, and its dispersal 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 transport cysts from one pool or complex to another on tires, shoes (including the shoes of biologists conducting surveys or restoration work), pet fur, etc. Results of a genetic study on San Diego fairy shrimp indicate there may be 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 genetic diversity of the species (Bohonak 2005). Similar genetic analyses have not been conducted for Riverside fairy shrimp, so we have no information on the potential adverse effects of human disturbance in vernal pools on the overall genetic composition and diversity of Riverside fairy shrimp.

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 access and disturbance in Riverside fairy shrimp habitat on foot or on motorized or non-motorized vehicles affects the species directly by crushing Riverside fairy shrimp cysts. Studies have demonstrated that cysts of the alkali fairy shrimp (*Branchinecta mackini*, a species common in southern California) are susceptible to crushing (Eriksen et al. 1986; Hathaway et al. 1996), though not necessarily under the low forces predicted in laboratory experiments carried out by Hathaway et al. (1996). This, coupled with the fact that fairy shrimp are found in vernal pool complexes which have been impacted by vehicle use and trampling (for examples, see City of San Diego 2004, 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 Riverside 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 significant threat to the Riverside fairy shrimp (58 FR 41384). This threat was reported as having occurred on virtually all remaining vernal pool complexes and to have resulted in soil compaction, and alteration of the hydrology of the pools. The use of OHVs continues to threaten Riverside fairy shrimp habitat throughout much of its range (Appendix 1); OHV threats on MCB Camp Pendleton are discussed above in the “Military Activities” section of this review. Cars, motorcycles, and bicycles can crush fairy shrimp cysts (see discussion above) and generally degrade or destroy Riverside fairy shrimp habitat. For example, three pools in the J14 complex on Otay Mesa previously documented to contain fairy

shrimp no longer pond due to OHV activity (Greg Mason, Senior Scientist, Helix Environmental Planning, pers. comm., 2007). Service files show that threats from recreational OHV use have increased since listing and continue to pose a substantive threat to the Riverside fairy shrimp. This threat is especially pervasive in Otay Mesa due to OHV use associated with Border Patrol activities (City of San Diego 2006), which have created many unauthorized roads and trails 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 Riverside fairy shrimp and its habitat from recreational and other OHV users.

To a lesser degree, OHV use for airport maintenance, emergency response (e.g., fire suppression and aviation emergencies), and law enforcement actions may impact Riverside fairy shrimp and its habitat in various locations while providing vital services (Bauder 1986a, 1986b, 1987). The one pool occupied by the Riverside fairy shrimp in Ramona was impacted by OHV use associated with airport maintenance activities (Robert MacAller, Principal, RECON, pers. comm., 2007). Fire suppression activities may impact occupied vernal pools and Riverside fairy shrimp due to use of OHVs to move people and equipment in response to wildfires and/or creation of firebreaks. Many vernal pools occupied by the Riverside fairy shrimp occur within or adjacent to large open space areas that are prone to fire. For example, the single occupied pool on MCAS Miramar was burned during the 2003 wildfires. Occupied vernal pools also occur near the Ramona and MCAS Miramar Airports where airport maintenance and aviation emergency response may occur.

Service files show that almost all remaining Riverside fairy shrimp habitat is threatened to some degree by increasing human access and disturbance. To lessen these impacts, the Service typically recommends a 100-foot (30.5-meter) habitat buffer in between new development and the watershed boundary of preserved or restored vernal pools, although this is not always implemented. Fencing is often implemented to limit or minimize human intrusion, and the secure nature of fenced sites (e.g., Brown Field, a secure airport site) keeps humans from recreating within vernal pools and helps to limit illegal dumping and litter; however, even secure sites are impacted by runoff, pollution, and nonnative plants. On MCB Camp Pendleton, personnel are instructed to avoid driving OHVs through vernal pools during military maneuvers (intrusion on foot 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). The listing rule discusses the threat of human trampling on Otay Mesa, which historically has been a common area for travel from Mexico to the U.S. Since listing of the Riverside fairy shrimp, fences have been erected along the border that should help minimize this threat. 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 not identified in the listing rule as a threat to Riverside fairy shrimp; the possibility that pesticides likely pose a threat to the species has since been recognized. Riverside fairy shrimp may be exposed to pesticides used to control weeds and insects. Herbicides are commonly used to control weeds outside (e.g., for roads, farms and residential landscaping) and even within (i.e., for enhancement/restoration projects) Riverside fairy shrimp habitat. One study showed that the commonly used herbicide Roundup[®] may pose a risk to San Diego fairy shrimp (Ripley et al. 2002); this pesticide is thus likely to pose a threat to Riverside fairy shrimp as well. Pesticide applications for the control of mosquito larvae have become more common to combat West Nile Virus. Although at this time the degree of this threat to Riverside 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 significant threat to Riverside 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 Riverside fairy shrimp habitat. The Service is currently undertaking research to determine the effects of some pesticides on the species.

Other control agents include *Bacillus thuringiensis* and *Bacillus sphaericus*, naturally occurring soil bacteria that act as larvicides commonly used to control mosquitoes and blackflies; and methoprene, an insect growth regulator commonly used as a pesticide. Use of these control agents has been proposed in occupied Riverside fairy shrimp habitat, though the effects of these vector control agents on the Riverside fairy shrimp are unknown. A study aimed at determining the effects of these agents on Riverside fairy shrimp is currently underway (see Species-specific Research and/or Grant-supported Activities section above).

Runoff from adjacent development may also introduce pollutants that could be toxic to the species including pesticides, 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 cysts from moving from the soil into the water column if they are able to hatch.

Clear, conclusive data quantifying the effects of the indirect impacts of development discussed above on Riverside fairy shrimp are lacking. We do not know how such effects may alter the demographics, genetic makeup, or robustness of Riverside fairy shrimp occurrences. We do not currently have a means of quantifying the abundance of Riverside fairy shrimp within a pool or complex; we can only determine presence or absence of the species. Thus, we are not able to detect changes 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, negatively impact Riverside fairy shrimp. More study is needed to accurately assess the magnitude and extent of the threat to Riverside fairy shrimp from the indirect impacts of development. However, as more land is 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, Orange, and Riverside counties). Based on the fragmented nature of the approximately 59 ac (24 ha) 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 Riverside fairy shrimp throughout its extant range.

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 (58 FR 41384). 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 the cyst bank could occur. 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 Riverside 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 shifts induced 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 habitat, 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). It is highly probable that California winters will 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. However, they are 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 the fairy shrimp are unknown, the effect of shifting temperatures on winter storm events and pool conditions have the potential to adversely affect Riverside fairy shrimp. This species may disappear from some areas to be replaced by more tolerant species. 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 occurrences, even where occurrences 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 (Bohanak 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 Riverside 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 identified fire as a stochastic event that could greatly impact Riverside fairy shrimp. The species was only known to inhabit 5 sites at that time, and it was apparently believed that fire could extirpate the population of a given site which, due to the fragmented and restricted nature of the habitat, could not be re-colonized. We now know that the threat of species extinction due to stochastic extirpation to be lower than what was thought at listing since more occupied complexes have been identified. However, a large fire event affecting MCAS Miramar (where there are only 3 occupied pools in relatively close proximity) or on Otay Mesa could result in significant impacts to the species in those areas, which could constitute a major loss to the genetic diversity of the species if fairy shrimp are in fact impacted by fire.

Though there is not much information available detailing the actual effects of fire on Riverside fairy shrimp, the information that does exist indicates that Riverside 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 Riverside fairy shrimp habitat may result in more intense fires that could have deleterious effects on cyst viability (Wells et al. 1997). Also, these studies looked at fire effects on San Diego fairy shrimp, and it is possible that Riverside fairy shrimp cysts may be more sensitive to fire.

There is also very little information available regarding impacts of fire on hatched fairy shrimp in water-filled pools. After hatching, Riverside 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 Riverside 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 Riverside fairy shrimp habitat where occurrences have been extirpated, as well as causing increased indirect effects to pool complexes from human access and disturbance. Additionally, OHV use continues to be a significant threat to the Riverside fairy shrimp, especially on Otay Mesa in San Diego County and throughout Riverside County. Increased management and maintenance of habitat is needed to counteract these threats. The magnitude of the impact of pesticides, drought and climate change, and fire on Riverside 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 Riverside 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 Riverside fairy shrimp occurrences have been identified since completion of the Recovery Plan, and the status of several complexes identified in Appendixes F and G of the Recovery Plan has changed. Despite these problems with the Recovery Plan and those discussed below, the plan provides useful guidance for recovering Riverside 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 Riverside 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 Riverside fairy shrimp conservation and recovery. The recovery criteria for stabilization and downlisting the Riverside fairy shrimp are summarized below, and include only those portions relevant to Riverside fairy shrimp:

Criterion 1. *In order to maintain genetic diversity and population stability of the listed species:*

Existing vernal pools currently occupied by Riverside fairy shrimp and their associated watersheds should be secured from further loss and degradation in a configuration that maintains habitat function and species viability;

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.

(Note: Of the vernal pool complexes identified as occupied by Riverside fairy shrimp in the Recovery Plan, only the O'Neill complex and the J4 and J6 portions of the J4-7 complex are not also listed in Appendix F of the Plan.)

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 of 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 (30.5 meters) measured from the outer edge of the watershed in most cases) reduces intrusion by pedestrians and OHV recreators, trash accumulation and dumping, and other indirect effects of habitat fragmentation resulting from 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 (see Appendices 1 and 2 of this 5-year review). Appendix 1 of this 5-year review lists all 45 currently occupied complexes, including some that have been identified since listing and/or since the Recovery Plan was finalized, and 12 complexes that have been extirpated since listing or for which status is unknown. Appendix 2 lists 130 complexes listed in Appendices F and G of the Recovery Plan that are not occupied by Riverside fairy shrimp. Overall, the Recovery Plan indicated a total of approximately 155 complexes that should be secured, including approximately 112 complexes (20 of which are occupied) listed in Appendix F as necessary to stabilize the species, and 43 complexes (4 of which are 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 (17 occupied) and Appendix G only 25 complexes (1 occupied) because many complexes were grouped together in these two tables in ways that are not useful for monitoring 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 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 57 complexes (including 45 complexes where the species is extant) (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 6 of the 20 occupied complexes (about 30 percent) listed in Appendix F of the Recovery Plan, and 1 of the 4 occupied complexes (25 percent) listed in Appendix G of the Recovery Plan have been at least partially conserved; 8 listed in Appendix F (40 percent) and 1 listed in Appendix G (25 percent) are on military land on which Riverside fairy shrimp is covered by an INRMP and thus (at least partially) meet this criterion (see Appendix 1 in this 5-year review). However, maintenance and monitoring for most restored and preserved vernal pools have not been guaranteed in perpetuity. At least 3 occupied complexes listed in Appendix F of the Recovery Plan, and 2 occupied complexes in Appendix G, are proposed for development. Of the 23 complexes listed in Appendices F and G of the Recovery Plan that have ever been known to be occupied by Riverside fairy shrimp, 8 complexes (35 percent) contain 1 or more pools that have been lost to development or substantially degraded by other impacts (see Appendix 1 of this 5-year review). Approximately 4 of the complexes listed in Appendices F and G of the Recovery Plan that have ever been known to be occupied by the Riverside fairy shrimp (17 percent) occur (at least partially) 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 Riverside fairy shrimp habitat; Riverside 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 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 improved and clarified as described above 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 of the 155 complexes (21 percent) listed in Appendices F and G (occupied and not occupied by Riverside fairy shrimp) have been at least partially conserved, and 54 are on military land (35 percent) (Appendices 1 and 2). Approximately 36 percent of the total 45 complexes identified as occupied by Riverside fairy shrimp have are at least partially conserved and 27 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 Riverside 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 by repairing damage inflicted on complexes by those threats identified. Since its listing, the Carlsbad Fish and Wildlife Office has issued 24 biological opinions under Section 7 of the Act and 4 approvals under section 10 of the Act for the Riverside fairy shrimp. These opinions outline avoidance and minimization measures that include enhancement and restoration of Riverside fairy shrimp habitat. Based on site visits and our review of monitoring reports, several restoration efforts appear to have successfully restored appropriate hydrology and transferred Riverside fairy shrimp into the restored pools; for example Arnie's Point and 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 should be achieved in other areas in the future. Long-term monitoring of restored pools will help demonstrate the persistence of Riverside 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 do not have any way of quantifying numbers of Riverside fairy shrimp within vernal pools, and therefore cannot determine whether actual population levels are stabilized, increasing, or decreasing. In section VI below ("Recommendations for Actions over the Next 5 Years"), we recommend research to establish methodologies for monitoring fairy shrimp abundance and trends.

IV. SYNTHESIS

Riverside fairy shrimp was listed in 1993 primarily due to the threat of development throughout the range of the species. By that time, vernal pool habitat in San Diego County had declined by an estimated 97 percent (T. Oberbauer, Department of Planning and Land Use, San Diego County, pers. comm., 1990), and in Orange County, by an estimated 90 to 98 percent of the historical vernal pool habitat has been eliminated (F. Roberts, Service, pers. comm., 1993). Similar declines in habitat are believed to have occurred in Riverside and Ventura Counties, and to a lesser degree in Baja California, Mexico, and all pools in Los Angeles County were believed to have been lost (58 FR 41384). At the time the listing rule was written, we were only aware of 5 vernal pool complexes within the U.S. and 2 complexes in Mexico that were known to be occupied by the Riverside fairy shrimp. All of these areas were considered to be under imminent threat of development or other impacts and very little of all remaining vernal pool habitat was protected from ongoing development pressures. The impacts of development on Riverside fairy shrimp and its habitat have been greatly reduced by the protections afforded the species by the Endangered Species Act. Despite protections, since listing at least 9 and as many as 12 occupied vernal pool complexes have been lost or no longer support this species, of the overall total of 57 known complexes identified in our current database.

The overall distribution of complexes known to be occupied by Riverside fairy shrimp has increased since listing from 5 complexes within the U.S. to 45 vernal pool complexes in the U.S. that are known to be currently occupied by the Riverside fairy shrimp. All but one of these additional occurrences were likely in existence at the time the species was listed, but had not been identified, and therefore were not included in the analyses that led to the listing of the species. The species has also been introduced into restored/enhanced vernal pools as part of vernal pool restoration projects: approximately 8 acres (3 ha) of habitat has been restored since listing (compared to the approximately 7 acres (3 ha) which have been lost). The additional occurrences increase the conservation and recovery potential of Riverside fairy shrimp by contributing to the resilience of this species via population redundancy; i.e., more occurrences are known to be available to contribute to sustaining the species in the event some occurrences are extirpated.

Approximately 16 occupied complexes (38 percent) 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. Service files indicate that currently proposed development is expected to impact at least 10 occupied vernal pool complexes (approximately 22 percent of all known occupied complexes or 63 percent of occupied pools on private lands).

Approximately 24 percent of known occupied complexes occur on military lands, including 8 complexes on MCB Camp Pendleton that contain 111 individual occupied pools. Therefore, although military lands only contain 24 percent of known occupied complexes, these lands likely support more than 24 percent of the total population of Riverside fairy shrimp. Vernal pool sites on military lands are not considered completely protected because many pools occur in active training areas. However, these lands are managed in part for Riverside 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 Riverside fairy shrimp on military lands.

Approximately 36 percent of remaining occupied vernal pool complexes have been conserved on public lands 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 Riverside fairy shrimp within plan boundaries, these plans have not yet met the conservation goals for Riverside 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, Riverside 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 Riverside fairy shrimp habitat is threatened to some degree by indirect effects 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 Riverside fairy shrimp habitat to development. Nonnative plants also threaten Riverside fairy shrimp throughout the range of the species. Off-highway vehicle use by recreators, law enforcement (including Border Patrol), and the military threatens this species throughout much of its range. Riverside 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 extant 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 Riverside 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 Riverside fairy shrimp on military lands, which support the greatest extent of known occupied habitat. Furthermore, we expect additional conservation, 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 Riverside 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 1-4 is needed to 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. Conduct a study of the genetic distribution of Riverside fairy shrimp analogous to the San Diego fairy shrimp study (Bohonak 2005).
4. 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 Riverside 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
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 Riverside fairy shrimp survey protocol should be updated to include acquisition of this abundance data. The defined abundance ranges should be used to model population viability analysis (PVA) for Riverside fairy shrimp, and as standards for determining Riverside 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 information available for the Riverside 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.

VII. REFERENCES CITED

5. REFERENCES

- Battle, J. and S.W. Golladay. 2003. Prescribed fire’s impact on water quality of depressional wetlands in southwestern Georgia. *American Midland Naturalist* 150(1):15-25.
- Bauder, E. T. 1986a. San Diego Vernal Pools: Recent and projected losses; their condition; and threats to their existence, 1979-1990. Report prepared for Endangered Plant Project, California Department of Fish and Game, Sacramento, California.
- Bauder, E. T. 1986b. Threats to San Diego vernal pools and case study in altered pool hydrology. Pages 209-213 In: T.S. Elias (editor). *Conservation and Management of Rare and Endangered Plants*. Proceedings from a Conference of the California Native Plant Society.
- Bauder, E. T. 1987. Species assortment along a small-scale gradient in San Diego vernal pools. PhD Dissertation. University of California Davis/San Diego State University, Davis, California.
- Bauder, E. T. 2005. The effects of an unpredictable precipitation regime on vernal pool hydrology. *Freshwater Biology* 50: 2129-2135
- Beauchamp, M. L. and T. Cass. 1979. San Diego Vernal Pool Survey. California Department of Fish and Game Non-Game Wildlife Investigations. Endangered Plant Program 145, Job 1-10.
- Black, C. 2004. Focused sampling for listed branchiopod species at three sites in Riverside County.
- Black, C. (Ecological Restoration Service). 2007. Vernal pool regulatory surveys, MCAS Miramar, San Diego, California.
- Bohonak, Andrew J. 2005. Conservation genetics of the endangered fairy shrimp species *Branchinecta sandiegonensis*. MSCP Vernal Pool Inventory, City of San Diego. August 12, 2005.
- Bohonak, A. J., and D. G. Jenkins. 2003. Ecological and evolutionary significance of dispersal by freshwater invertebrates. *Ecology letters* 6: 783-796.

- Bonte, D., L. Lens, J. P. Maelfait. 2004. Effects of aerial dispersal, habitat specialization, and landscape structure on spider distribution across fragmented grey dunes. *Ecography* 27: 343-349.
- Branchiopod Research Group, The. 1996. Vernal Pool Faunal Survey Naval Air Station Miramar 1996. University of San Diego, San Diego, California.
- California Department of Finance. 2004. Population projections by race/ethnicity for California and its counties 2000–2050.
- California Natural Diversity Database (CNDDDB). 2008. RAREFIND, Natural Heritage Division. California Department of Fish and Game, State of California
- Cayan, D., M. Dettinger, I. Stewart, and N. Knowles. 2005. Recent changes towards earlier springs: early signs of climate warming in western North America? U.S. Geological Survey, Scripps Institution of Oceanography, La Jolla, California.
- Center for Natural Lands Management. 1997. Management Plan for the Barry Jones (Skunk Hollow) Wetland Mitigation Bank.
- Center for Natural Lands Management. 2006. Annual report for the fiscal year 2005 on the Barry Jones Wetlands Mitigation Bank (Skunk Hollow).
- City of San Diego. 1997. City of San Diego MSCP Subarea Plan. March 1997.
- City of San Diego. 2004. City of San Diego Vernal Pool Inventory 2002-2003. San Diego, California.
- City of San Diego. 2006. Draft Vernal Pool Management Plan.
- Dudek and Associates. 1998. Presence/absence survey for vernal pool branchiopods – Poinsettia Shores, San Diego County, California.
- Dudek and Associates. 2001a. Wet season presence/absence survey for vernal pool branchiopods for the San Juan Creek/San Mateo Creek Special Area Management Plan, Orange County, California.
- Dudek and Associates. 2001b. Wet season presence/absence survey for vernal pool branchiopods for the St. Jerome Church project site, City of San Diego, California.

- Dudek and Associates 2006. Southern Orange County Subregion Natural Community Conservation Plan/Master Streambed Alteration Agreement/Habitat Conservation Plan (Southern NCCP/MSAA/HCP). Part 1 Draft Southern NCCP/MSAA/HCP. Chapters 1-14 + Appendices.
- ECORP Consulting, Inc. 2006. Annual Report for the Highland Reserve South Open Space Preserve, Placer County, California. July 7, 2006 (Service File # 1-1-99-I-359). Prepared for the City of Roseville.
- Eng, L. L., D. Belk, and C. H. Eriksen. 1990. California Anostraca: Distribution, Habitat and Status. *Journal of Crustacean Biology* 10: 247-277.
- The Environmental Trust. 2003. West Otay Mesa A Environmental Preserve 2002 Annual Report.
- Eriksen, C. and D. Belk 1999. Fairy Shrimps of California's Puddles, Pools, and Playas. Mad River Press, Inc., Eureka, California.
- Eriksen, C. H., G. E. Prettyman, and J. E. Moeur. 1986. The effects of soil disturbance by off road vehicles on the eggs and habitat of playa lake crustaceans.- In: R. G. Zahary, ed., *Desert ecology; a research symposium*. Pp. 50-65. Southern California Academy of Sciences and Southern California Desert Studies Consortium. Los Angeles, California.
- ESA Associates. 2007. USFWS Vernal Pool Crustacean 5-Year Status Review, San Diego fairy shrimp, Final Draft. Prepared by ESA Associates, Sacramento, for the Carlsbad Fish and Wildlife Office.
- Field, C. B., G. C. Daily, F. W. Davis, S. Gaines, P. A. Matson, J. Melack, and N. L. Miller. 1999. *Confronting Climate Change in California. Ecological Impacts on the Golden State. A Report of the Union of Concerned Scientists and the Ecological Society of America.* 62 pages.
- Gifford, G. F. and R. H. Hawkins. 1978. Hydrologic impacts of grazing on infiltration: a critical review. *Water Resources Research* 14: 305-313.
- Glenn Lukos Associates. 1997. Fairy shrimp surveys within stockpond on property at corner of El Toro Road and Live Oak Canyon Road, adjacent to Saint Michaels Seminary, Orange County, California.
- Glenn Lukos Associates. 2001. Results of wet season surveys for the federally listed endangered Riverside fairy shrimp, Tijeras Creek Park site, Orange County, California.
- Glenn Lukos Associates. 2003. 90-day letter report of dry-season vernal pool branchiopod sampling at Grizzle Ranch for the Menifee Heights project in Winchester, Western Riverside County, California.

- Gonzalez, R. J., J. Drazen, S. Hathaway, B. Bauer, and M. Simovich. 1996. Physiological correlates of water chemistry requirements in fairy shrimps (Anostraca) from southern California. *Journal of Crustacean Biology* 16: 315-322.
- Hanes, W.T., B. Hecht, and L.P. Stromberg. 1990. Water relationships of vernal pools in the Sacramento region, California. Pages 49-60 in: D.H. Ikeda and R.A. Schlising (Editors). *Vernal pool plants: their habitat and biology*. Studies from the Herbarium Number 8, California State University, Chico, CA.
- Hanes, T. and L. Stromberg. 1998. Hydrology of vernal pools on non-volcanic soils in the Sacramento Valley. Pages 38-49. in: C. W. Witham, E. T. Bauder, D. Belk, W. R. Ferren Jr., and R. Ornduff (Editors). *Ecology, Conservation, and Management of Vernal Pool Ecosystems - Proceedings from a 1996 Conference*, California Native Plant Society, Sacramento, California.
- Hathaway, S. A. and M. A. Simovich. 1996. Factors affecting the distribution and co-occurrence of two southern Californian anostracans (Branchiopoda), *Branchinecta sandiegonensis* and *Streptocephalus woottoni*. *Journal of Crustacean Biology* 16(4): 669-677.
- Hathaway, S. A., D. P. Sheehan, and M. A. Simovich. 1996. Vulnerability of branchiopod cysts to crushing. *Journal of Crustacean Biology* 16(3):448-452.
- Helix Environmental Planning, Inc. 1997. Biological assessment for the Robinhood Ridge project.
- Helix Environmental Planning, Inc. 1998. 1998 Annual report – U.S. Fish and Wildlife protocol level wet season survey for San Diego and Riverside fairy shrimp (*Branchinecta sandiegonensis* and *Streptocephalus woottoni*). Prepared for Brown Field.
- Helix Environmental Planning, Inc. 2000. 2000 U.S. Fish and Wildlife protocol level dry season survey for San Diego and Riverside fairy shrimp (*Branchinecta sandiegonensis* and *Streptocephalus woottoni*). (Saddleback Meadows)
- Helix Environmental Planning, Inc. 2002a. 2002 Annual report – U.S. Fish and Wildlife protocol level dry season survey for San Diego and Riverside fairy shrimp (*Branchinecta sandiegonensis* and *Streptocephalus woottoni*). Prepared for County of Riverside Scott Road widening.
- Helix Environmental Planning, Inc. 2002b. County of San Diego – SR 905 – 2002 dry season fairy shrimp sampling results.
- Helix Environmental Planning, Inc. 2003. 2002/2003 Annual report – U.S. Fish and Wildlife protocol level wet season survey for San Diego and Riverside fairy shrimp (*Branchinecta sandiegonensis* and *Streptocephalus woottoni*) on the New Millennium project site.

- Helix Environmental Planning, Inc. 2004a. 2004 Annual report – U.S. Fish and Wildlife protocol level wet season survey for San Diego and Riverside fairy shrimp (*Branchinecta sandiegonensis* and *Streptocephalus woottoni*). Prepared for Western Pacific Housing; Candlelight East and West Village projects.
- Helix Environmental Planning, Inc. 2004b. 2004 Annual report – U.S. Fish and Wildlife protocol level dry season survey for San Diego and Riverside fairy shrimp (*Branchinecta sandiegonensis* and *Streptocephalus woottoni*). Prepared for Western Pacific Housing; Candlelight East and West Village projects.
- Helix Environmental Planning, Inc. 2005a. Vernal pools and upland vegetation maintenance and monitoring for Area A (year 3) and Area B (year 2), 2004-05 hydrological year. (For Arnie's Point).
- Helix Environmental Planning, Inc. 2005b. U.S. Fish and Wildlife protocol level wet season survey for San Diego and Riverside fairy shrimp (*Branchinecta sandiegonensis* and *Streptocephalus woottoni*) for the Arnaiz Parcel (for State Route-11).
- Helix Environmental Planning, Inc. 2006. U.S. Fish and Wildlife protocol level wet season survey for San Diego and Riverside fairy shrimp (*Branchinecta sandiegonensis* and *Streptocephalus woottoni*) for Anderson.
- Helm, B. 1998. Biogeography of eight large branchiopods endemic to California. Pages 124 - 139 in: Ecology, conservation, and management of vernal pool ecosystems - proceedings from a 1996 conference, C. W. Witham, E. T. Bauder, D. Belk, W. R. Ferren, Jr., and R. Ornduff, eds. California Native Plant Society, Sacramento, California. 285 pp.
- Holland, R.F. (1976). The vegetation of vernal pools: a survey. In Jain, S. (ed.), Vernal pools, their ecology and conservation. Institute of Ecology Publication No. 9: 11-15. (University of California, Davis)
- Holtz, Janette. 2003. A life History Study of the San Diego Fairy Shrimp (*Branchinecta sandiegonensis*). Master's thesis, University of San Diego.
- [IPCC] Intergovernmental Panel on Climate Change. 2007. Climate change 2007: the physical science basis. Summary for policymakers. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, IPCC Secretariat, World Meteorological Organization and United Nations Environment Programme, Geneva, Switzerland.
- Jones and Stokes. 2006. Final East Contra Costa County Habitat Conservation Plan / Natural Community Conservation Plan. October (J&S 01478.01) San Jose, California
- Keeler-Wolf, T., D. R. Elam, K. Lewis, and S. A. Flint. 1998. California vernal pool assessment. Preliminary report. California Department of Fish and Game. Wetlands Inventory and Conservation Unit, Sacramento, California.

- Keeley, J.E. and P.H. Zedler. 1998. Characterization and global distribution of vernal pools. Pages 1-14 in: C.W. Witham, E.T. Bauder, D. Belk, W.R. Ferren Jr., and R. Ornduff (Editors). Ecology, Conservation, and Management of Vernal Pool Ecosystems – Proceedings from a 1996 Conference. California Native Plant Society, Sacramento, CA. 1998.
- Krapu, G. L. 1974. Foods of breeding pintails in North Dakota. *Journal of Wildlife Management* 38(3): 408-417.
- March Air Reserve Base. 2005. Final Integrated Natural Resources Management Plan. March Air Reserve Base, California.
- Marty, J. 2005. Effects of cattle grazing on diversity in ephemeral wetlands. *Conservation Biology* 19: 1626-1632.
- Mattoni, R. and T. R. Longcore. 1997. The Los Angeles coastal prairie, a vanished community. *Crossosoma* 23(2): 71-102.
- [MCAS Miramar] Marine Corps Air Station Miramar. 2005. A study of the effects of wildfire on vernal pools 2001 – 2003.
- [MCAS Miramar] Marine Corps Air Station Miramar. 2006. Integrated Natural Resources Management Plan (INRMP) for Marine Corps Air Station Miramar, California.
- [MCB Camp Pendleton] Marine Corps Base Camp Pendleton. 2001. Integrated Natural Resources Management Plan (INRMP) for MCB Camp Pendleton, California.
- [MCB Camp Pendleton] Marine Corps Base Camp Pendleton. 2005. Biological Assessment for the Assault Breacher Vehicle. MCB Camp Pendleton, California. March 2005.
- [MCB Camp Pendleton] Marine Corps Base Camp Pendleton. 2007. Marine Corps Integrated Natural Resources Management Plan, U.S. Marine Corps Base, Camp Pendleton, California.
- McLaughlin, J. F., J. J. Hellmann, C. L. Boggs, and P. R. Ehrlich. 2002. Climate hastens population extinctions. *PNAS* 99: 6070 – 6074
- Michael Brandman Associates. 2006. 90-day report – Dry season fairy shrimp sampling – Granite Homes Garbani Property, Menifee Area, Unincorporated Riverside County, California.
- Mountains Recreation and Conservation Authority. 2006. Tierra Rejada Vernal Pool Preserve – 2005 Monitoring Report

- Ogden Environmental and Energy Services. 1994. NAS Miramar Anostracan survey – MCAS Tustin and El Toro relocation project.
- [PCR] Planning Consultants Research. 1998. Wetland delineation and vernal pool technical report for the proposed conservation bank on the Southern California Edison Viejo Substation property, Orange County, California.
- Philippi, T. E., M. A. Simovich, E. T. Bauder, and J. A. Moorad. 2001. Habitat ephemerality and hatching fractions of a diapausing anostracan (Crustacea: Branchiopoda). *Israel Journal of Zoology* 47: 387-395.
- Principe, Z. 2008. Vernal pool and branchiopod survey report for Inland Valley Professional Center project.
- Proctor, V. W. 1964. Viability of crustacean eggs recovered from ducks. *Ecology* 45: 656-658.
- Pyke, C. R. 2004. Habitat loss confounds climate change impacts. *Frontiers in Ecology and the Environment* 2: 178-182.
- Pyke, C. R. 2005a. Assessing climate change impacts on vernal pool ecosystems and endemic branchiopods. *Ecosystems* 8: 95-105.
- Pyke, C. R. 2005b. Interactions between Habitat Loss and Climate Change: Implications for Fairy Shrimp in the Central Valley Ecoregion of California, USA. *Climatic Change* 68: 199-218.
- Pyke, C.R., and J. Marty. 2005. Cattle grazing mediates climate change impacts on ephemeral wetlands. *Conservation Biology* 19(5):1619-1625.
- RECON. 1997. Dennery Canyon vernal pool, coastal sage scrub, and mulefat scrub restoration and preservation plan. Section 404/Section 7 mitigation and monitoring plan for California Terraces and Otay Corporate Center.
- RECON. 1998a. Final First-Year Fairy Shrimp Survey Report for a 60-Acre Area of the Back Basin of Lake Elsinore. RECON Number 2943B.
- RECON. 1998b. Fairy shrimp surveys at March Air Reserve Base, Riverside County, California.
- RECON. 1998c. Fairy shrimp surveys at Los Angeles International Airport.
- RECON. 2001a. Post-survey notification of dry season fairy shrimp surveys 28 pools on Otay Mesa Area 2 Secondary Fence project, San Diego County.
- RECON. 2001b. Final Fairy Shrimp Survey Report: Results of Two Consecutive Years of Wet Season Surveys on Camp Pendleton, California.

- RECON. 2004. Year 3 vernal pool restoration monitoring report for the Wire Mountain Housing Area, Marine Corps Base Camp Pendleton, San Diego County, California. Unpublished report prepared for Southwest Division Naval Facilities Engineering Command. RECON #3421B. 44 pp. + Attachments 1-2.
- RECON. 2007. Results of 2004-2005 vernal pool surveys and summary of available vernal pool data on MCB Camp Pendleton, San Diego, California.
- Ripley, B. J., K. C. Davis, B. J. Carter, and M. A. Simovich. 2002. Toxicity of Malathion and Roundup[®] to the San Diego Fairy Shrimp. 2002-2003 Transactions of the Western Section of the Wildlife Society 38/39: 13-21.
- Ripley, B. J., J. H. Holtz, and M. A. Simovich. 2004. Cyst bank life-history model for a fairy shrimp from ephemeral ponds. *Freshwater Biology* 49: 221-231.
- [SAIC] Science Applications International Corporation. 2004. 90-day letter report of dry-season vernal pool branchiopod sampling at Camp Pendleton in San Diego County, California.
- [SANDAG] San Diego Association of Governments 2007. San Diego Region City/County Population and Housing Estimates 1/1/2007.
http://www.sandag.org/uploads/publicationid/publicationid_485_637.pdf
- [Service] U.S. Fish and Wildlife Service. 1992. Biological opinion on Marine Corps reserve tank training and vernal pool habitat restoration, Naval Air Station, Miramar, (1-6-92-F-31).
- [Service] U.S. Fish and Wildlife Service. 1996a. Biological Opinion on the construction of a 4.7 mile extension of Antonio Parkway, Orange County, California (1-6-97-F-2).
- [Service] U.S. Fish and Wildlife Service. 1996b. Biological opinion and conference report on the proposed San Mateo Point family housing, MCB Camp Pendleton, San Diego County, California (1-6-96-F-30).
- [Service] U.S. Fish and Wildlife Service. 1997. Biological opinion/Conference opinion for Pardee Construction Company, Otay Mesa, San Diego, California (1-6-95-F-35).
- [Service] U.S. Fish and Wildlife Service. 1998a. Recovery Plan for Vernal Pools of Southern California U.S. Fish and Wildlife Service, Portland, Oregon. 113+ pp.
- [Service] U.S. Fish and Wildlife Service. 1998b. Biological opinion on the Ramona Airport improvement project, County of San Diego, California (1-6-98-F-46).
- [Service] U.S. Fish and Wildlife Service. 1998c. Biological opinion/Conference opinion for Robinhood Homes Residential project (No. 97-20133 DAZ), Otay Mesa, San Diego County, California (1-6-97-F-57).

- [Service] U.S. Fish and Wildlife Service. 1999a. Formal section 7 consultation on Live Oak Plaza commercial and residential development project, Orange County, California (1-6-99-F-15).
- [Service] U.S. Fish and Wildlife Service. 1999b. Biological opinion for the San Diego Air Commerce Center at Brown Field Master Plan, City of San Diego, San Diego County, California (1-6-99-F-65).
- [Service] U.S. Fish and Wildlife Service. 2000a. Formal section 7 consultation/conference for issuance of a section 10(a)(1)(B) permit to Pacific Bay Properties, Rancho Bella Vista, Western Riverside County (1-6-00-F-12).
- [Service] U.S. Fish and Wildlife Service. 2000b. Intra-Service Formal Section 7 Consultation/Conference on the Issuance of a Section 10(a)(1)(B) Permit to Four Public Agencies and Nine Private Entities for the Assessment District 161 Subregional Habitat Conservation Plan, Western Riverside County (1-6-01-F-725.2)
- [Service] U.S. Fish and Wildlife Service. 2000c. Biological opinion on the Advanced Amphibious Assault Vehicle development and operational testing, MCB Camp Pendleton, San Diego County, California (1-6-00-F-40).
- [Service] U.S. Fish and Wildlife Service. 2000d. Biological opinion on the proposed construction of Otay Mesa High School site for the Sweetwater Union High School District, San Diego County, California (1-6-99-F-77).
- [Service] U.S. Fish and Wildlife Service. 2001a. Biological opinion for issuance of an incidental take permit to Redhawk Communities, LLC, for the Redhawk Development Habitat Conservation Plan, Riverside County, California.
- [Service] U.S. Fish and Wildlife Service. 2001b. Biological opinion on the Saddleback Meadows residential development project, Orange County, California (1-6-01-F-1023).
- [Service] U.S. Fish and Wildlife Service. 2001c. Reinitiation of the biological opinion for the Ramona Airport improvement project, County of San Diego, California (1-6-98-F-833.3-R1)
- [Service] U.S. Fish and Wildlife Service. 2002a. Biological Opinion for Remedial Action at Sites 2 and 17, Former Marine Corps Air Station El Toro, Orange County, California (1-6-F-02-1202).
- [Service] U.S. Fish and Wildlife Service. 2002b. Biological opinion on the linear vernal pool on Arnie's Point portion, a part of the 14-mile border fence, road and lighting project along the US/Mexico border, San Diego County, California (1-6-01-F-1089.12).
- [Service] U.S. Fish and Wildlife Service. 2003a. Formal Section 7 Consultation for Highpointe Communities, Clayton Ranch Project, Riverside County, California

- [Service] U.S. Fish and Wildlife Service. 2003b. Formal consultation for the Advanced Amphibious Assault Vehicle program at MCB Camp Pendleton, San Diego County, California.
- [Service] U.S. Fish and Wildlife Service. 2003c. Amendment to formal section 7 consultation on the Expeditionary Fighting Vehicle (formerly the Advanced Amphibious Assault Vehicle) development and operational testing, MCB Camp Pendleton, San Diego County, California.
- [Service] U.S. Fish and Wildlife Service. 2003d. Biological Opinion for the Sunroad Centrum project on Otay Mesa , San Diego County, California.
- [Service] U.S. Fish and Wildlife Service. 2003e. Biological opinion for the Area II project, a portion, a part of the 14-mile border infrastructure system, road and lighting project along the US/Mexico border, San Diego County, California (1-6-03-F-1089.17).
- [Service] U.S. Fish and Wildlife Service. 2004a. Biological and Conference Opinion for Sampling of Installation Restoration Program (IRP) Site 1 Ephemeral Pond on Former Marine Corps Air Station El Toro, Orange County, California.
- [Service] U.S. Fish and Wildlife Service. 2004b. Biological opinion and Conference opinion for the tertiary treatment plant and associated facilities, MCB Camp Pendleton, San Diego County, California.
- [Service] U.S. Fish and Wildlife Service. 2004c. Biological opinion for the State Route 905 project, San Diego County, California (1-6-04-F-2296.5).
- [Service] U.S. Fish and Wildlife Service. 2004d. Biological Opinion and Conference Opinion for the Expeditionary Fighting Vehicle Expanded Testing Program at Marine Corps Base Camp Pendleton, San Diego County, California
- [Service] U.S. Fish and Wildlife Service. 2005a. Biological opinion for Los Angeles International Airport Master Plan, City of Los Angeles, Los Angeles County, California.
- [Service] U.S. Fish and Wildlife Service. 2005b. Programmatic biological opinion for the Rail Corridor from Orange County border south to southern Oceanside for operations and maintenance, and six double-track projects in San Diego County, California (1-6-05-P-4123.2).
- [Service] U.S. Fish and Wildlife Service. 2005c. Biological opinion for impacts associated with the base-wide fuel optimization program, MCB Camp Pendleton, San Diego County, California.

- [Service] U.S. Fish and Wildlife Service. 2005d. Formal section 7 consultation and biological opinion on fielding of the Assault Breacher Vehicle, MCB Camp Pendleton, San Diego County, California.
- [Service] U.S. Fish and Wildlife Service. 2005e. 2005b. Training-related impacts to vernal pool group 68, Oscar Two Training Area, Marine Corps Base Camp Pendleton, San Diego County, California. Letter (FWSMCBCP- 4449.1) to the U. S. Marine Corps, Marine Corps Base Camp Pendleton. On file, U. S. Fish and Wildlife Service, Carlsbad Fish and Wildlife Office, Carlsbad, California.
- [Service] U.S. Fish and Wildlife Service. 2007a. Biological opinion for operations and maintenance activities at Los Angeles International Airport, City of Los Angeles, Los Angeles County, California (1-6-01-F-1012.7).
- [Service] U.S. Fish and Wildlife Service. 2007b. Draft Fish and Wildlife Coordination Act Report for the Cactus/Heacock Channels Flood Control Project, City of Moreno Valley and March Air Reserve Base, Riverside County, California
- [Service] U.S. Fish and Wildlife Service. 2007c. Intra-Service Formal Section 7 Consultation/Conference for Issuance of an Endangered Species Act Section 10(a)(1)(B) Permit (TE144113-0, TE144140-0, and TE144105-0) for The Southern Orange Natural Community Conservation Plan/ Master Streambed Alteration Agreement/ Habitat Conservation Plan, Orange County, California.
- [Service] U.S. Fish and Wildlife Service. 2008. Draft Formal Section 7 Consultation for Marine Corps Forces Special Operations Command Program (MARSOC), Marine Corps Base Camp Pendleton, San Diego County, California (FWS-MCBCP-07B0015-08F0125).
- Silveira. 1998. Avian Uses of Vernal Pools and Implications for Conservation Practice. Pages 92-106 in: C.W. Witham, E.T. Bauder, D. Belk, W.R. Ferren Jr., and R. Ornduff (Editors). Ecology, Conservation, and Management of Vernal Pool Ecosystems – Proceedings from a 1996 Conference. California Native Plant Society, Sacramento, CA. 1998.
- Simovich M. A. 1985. Analysis of a hybrid zone between the spadefoot toads *Scaphiopus multiplicatus* and *Scaphiopus bombifrons*. Ph.D. dissertation, University of California, Riverside, CA.
- Simovich, M. A. and S. A. Hathaway. 1997. Diversified bet-hedging as a reproductive strategy of some ephemeral pool anostracans. *Journal of Crustacean Biology*. 17: 38-44.
- Simovich, M. A. 1998. Crustacean biodiversity and endemism in California's ephemeral wetlands. Pages 107-118 in: C. W. Witham, E. T. Bauder, D. Belk, W. R. Ferren Jr., and R. Ornduff (Editors). Ecology, Conservation, and Management of Vernal Pool Ecosystems - Proceedings from a 1996 Conference, California Native Plant Society, Sacramento, California.

- Simovich, M. A. 2005. Considerations for the Management of Vernal Pool Faunal Communities USDA Forest Service Gen. Tech. Rep. PSW-GTR-195.
- Swanson, G. A., M. I. Meyer, and J. R. Serie. 1974. Feeding ecology of breeding blue-winged teals. *Journal of Wildlife Management* 38(3): 396-407.
- Thorne, R. F. 1984. Are California's vernal pools unique? Pp. 1-8, in: *Vernal pools and intermittent streams* (S. Jain and P. Moyle, eds.). Univ. California Inst. Ecol. Publ., 28:1-280.
- Tom Dodson & Associates. 2003a. 90-day letter of vernal pool branchiopod sampling at the Rainbow Canyon project in Riverside County, California.
- Tom Dodson & Associates. 2003b. 90-day letter of dry-season vernal pool branchiopod sampling at the Rainbow Canyon project in Riverside County, California.
- URS. 2005. Year 2005 90 day report for vernal pool branchiopod surveys at East Otay Mesa, CA for the Caltrans SR-11 study area.
- [USEPA and Corps] U.S. Environmental Protection Agency and U.S. Army Corps of Engineers. 2007. Memorandum: Clean Water Act jurisdiction following the U.S. Supreme Court's decision in *Rapanos v. United States* and *Carabell v. United States*. June 5, 2007.
- U. S. Marine Corps. 1998. Letter to the U. S. Fish and Wildlife Service regarding the fill of two Class IV isolated ephemeral wetlands on Marine Corps Base Camp Pendleton. June 29, 1998. 5090.18C ENVSEC/521.
- U. S. Marine Corps. 1999. Letter to the U. S. Fish and Wildlife Service regarding the discing of vernal pools in Wire Mountain Housing Area, Marine Corps Base, Camp Pendleton. October 8, 1999. 5090.46 ENVSEC/521.
- U. S. Marine Corps. 2002. Range and Training Regulations. Base Order P3500.1L. Marine Corps Base Camp Pendleton, California. March 2002.
- U. S. Navy. 2001. P-634 final biological assessment for the Armor/Anti-Armor Tracking Range, Marine Corps Base, Camp Pendleton, California. Prepared for U. S. Dept. of the Navy, Southwest Division Naval Facilities Engineering Command, San Diego, California. On file (FWS-MCBCP-1789), U. S. Fish and Wildlife Service Carlsbad Fish and Wildlife Office, Carlsbad, California.
- U. S. Navy. 2002. Biological assessment, Advanced Amphibious Assault Vehicle: Effects on listed terrestrial and aquatic species at MCB Camp Pendleton. Prepared for U. S. Dept. of the Navy, Southwest Division Naval Facilities Engineering Command, San Diego, California. October 2002. On file (FWS-MCBCP-3223), U. S. Fish and Wildlife Service Carlsbad Fish and Wildlife Office, Carlsbad, California.

- Wegscheider, F.J. 2003. 90-day letter report of dry-season vernal pool branchiopod sampling at Grizzle Ranch for the Menifee Heights project in Winchester, Western Riverside County, California.
- Wegscheider, F.J. 2004. 90-day letter report of wet-season vernal pool branchiopod sampling at Grizzle Ranch for the Menifee Heights project in Winchester, Western Riverside County, California.
- Wegscheider, F.J. (Cadre Environmental). 2006. 90-day letter report of dry-season vernal pool branchiopod sampling for the Pechanga Indian Reservation project site in Western Riverside County, California.
- Wells, M. L., S. A. Hathaway, and M. A. Simovich. 1997. Resilience of anostracan cysts to fire. *Hydrobiologia* 359: 199–202, 1997.
- Western Riverside County Regional Conservation Authority. 2006. Joint Project Review for Proposed Constrained Linkage #13, City of Temecula. JPR Log No. 05 09 06 03
- Wetzel, R.G. 1975. *Limnology*. W.B. Saunders Company, Philadelphia, Pennsylvania.
- Zedler, P. H., T. A. Ebert, M. L. Balko, and R.M. Beauchamp. 1979. A survey of vernal pools of Kearny Mesa, San Diego County, spring 1979. California. Report prepared for the Department of Transportation, San Diego, California.

Personal Communications and Observations

- MacAller, Robert (RECON). 2007. Letter to Julie Quinn (County of San Diego, Department of Public Works) dated January 29, 2007. Subject: Damage assessment for Ramona Airport vernal pool number C-20, Ramona, California.
- Mason, Greg (Helix). 2007. Electronic mail message to Patrick Gower (Service) dated July 10, 2007. Subject: Anderson.
- Roberts, Fred (Service). 1993. Internal memorandum to Ellen Berryman dated January 20, 1993. Subject: The status of vernal pools, *Orcuttia californica*, *Eryngium aristulatum* var. *parishii*, and Riverside fairy [shrimp] in Orange County.
- Stockwell, Kathleen. 2003. Facsimile to Jonathan Snapp-Cook (Service) dated November 13, 2003. Subject: Information regarding O'Neill Park/Clay Flats pond.
- Tran, Vihn (County of Orange). 2006. Personal communication to Chris Medak (Service), October 31, 2006
- Wynn, Susan (Service, Carlsbad Fish and Wildlife Office). 2007. Personal observation.

Appendix 1. Vernal pool complexes identified as occupied at listing of Riverside fairy shrimp in 1993 (58 FR 41384) and since listing

Complex Name	Location	Owner	Status	Major Threats	Needs	RSF	Recovery Plan Appendices
El Toro	City of Irvine, Orange County	U.S. Navy (will be 100% non-military once environmental remediation efforts are complete)	partially impacted by landfill remediation (Service 2002a); impacts repaired via DOD enhancement in 2005 (Service 2004a); potential restoration site for Los Angeles Airport	Nonnative plants	conservation; restoration; management	X	F
Saddleback Meadows	Unincorporated Orange County	Private	proposed development (Helix 2000; Service 2001b)	development; cattle	conservation; restoration; management	X	F
Antonio Parkway++	Unincorporated Orange County	County of Orange (within the San Juan Creek watershed)	developed (Service 1996a)			Xh	
Whiting Ranch (SCE Viejo Conservation Bank)	Unincorporated Orange County (Southern California Edison's Viejo Substation)	Southern California Edison	proposed mitigation bank (PCR 1998)	nonnative plants; OHV; fire protection	conservation; restoration; management	X	
Tijeras Creek++	City of Rancho Santa Margarita, Orange County	Private	not preserved (Glenn Lukos Associates 2001)	development; nonnative plants; OHV; fire protection	conservation; restoration; management	X	
Madrona Marsh++	City of Torrance, Los Angeles County	City of Torrance	conserved; potential restoration site for Los Angeles Airport (Mattoni and Longcore 1997)			Xh? (few cysts only)	
Chiquita Ridge	Unincorporated Orange County	Private	conserved (Dudek and Associates 2001a; Service 1996, 2007b)	nonnative plants; fire control	restoration; management	X	F

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Complex Name	Location	Owner	Status	Major Threats	Needs	RSF	Recovery Plan Appendices
O'Neill Park/ Clay Flats pond Property (CNDDDB occurrence 17)	Unincorporated Orange County	Private	proposed development (Kathleen Stockwell, pers. comm. 2003; CNDDDB 2008)	development; OHV; nonnative plants; fire control	conservation; restoration; management	X	
Radio Tower Road++	Unincorporated Orange County	Private	conserved; managed (Service 2007c; Dudek and Associates 2001a)	nonnative plants; fire control	restoration; management	X	
Live Oak Plaza++	Unincorporated Orange County	Private	conserved (Glenn Lukos Associates 1997; Service 1999a)	fragmentation; nonnative plants; fire control	restoration; management	X	
Skunk Hollow (known at listing)	Riverside County	(in the Barry Jones Wetland Mitigation Bank) The Center for Natural Lands Management	conserved; managed (Center for Natural Lands Management 1997, 2006; Service 2000a)	fragmentation; nonnative plants; edge effects		X	F
Field Pool (known at listing)	Riverside County (0.25 mile southeast of Skunk Hollow Pool)	County of Riverside	conserved; managed (LSA 2002; Service 2000b)	fragmentation; nonnative plants; edge effects	conservation easement	X	
Australia Pool++ (located in the Lake Elsinore back basin)	Riverside County (in Lake Elsinore back basin)	Private	not preserved (RECON 1998a)	development; fragmentation; nonnative plants; altered hydrology	conservation; restoration; management	X	
Schleuniger pool ++ (north of La Estrella Road)	Riverside County (north of La Estrella Road)	Private	impacted by adjacent construction activities and culvert – hydrology likely altered; not preserved; potential restoration site for Clayton Ranch (Service 2003a)	development; fragmentation; nonnative plants; OHV	conservation; restoration; management	X	

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Complex Name	Location	Owner	Status	Major Threats	Needs	RSF	Recovery Plan Appendices
Clayton Ranch++	Riverside County	Private	developed; pools created to offset development showing too much riparian influence, fairy shrimp have not yet been introduced.			Xh	
March Air Reserve Base++	Riverside County	U.S. Air Force	1 pool lost to unauthorized development; 1 remaining pool – not covered by INRMP (Service 2007b; RECON 1998b)		conservation; restoration; management	X (cysts)	
Scott Pool++	Riverside County (northeast of intersection of Scott Road and Menifee Road)	Private	not preserved (Helix 2002a)	development; fragmentation; nonnative plants; agriculture	conservation; restoration; management	X (cysts)	
Rainbow Canyon Pool++	Riverside County	Private	not preserved (Tom Dodson & Associates 2003a, b)	development; fragmentation	conservation; restoration; management	X	
Pechanga Pool (known at listing)	Riverside County	Private and Pechanga Reservation	not preserved (Wegscheider 2006)	agriculture; development	conservation; restoration; management	X	
Rancho California Road Pools++	Riverside County	Private	1 pool conserved?; proposed development (1 pool) (Black 2004)	development	conservation; restoration; management	X	
Redhawk++	Riverside County	Private	developed			Xh	
Schau pools	Riverside County	Private	1 of 2 pools impacted by construction activities onsite, but extant; not preserved (Principe 2008)	development	conservation; restoration; management	X	

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Complex Name	Location	Owner	Status	Major Threats	Needs	RSF	Recovery Plan Appendices
Johnson Ranch	Riverside County	Private	on conserved lands; mitigation for Redhawk (Service 2001a); Riverside fairy shrimp transferred from Redhawk; occupy 5 of 7 created pools	nonnative plants; riparian plant species colonizing – hydrology issues	management	X	
Grizzle Ranch++	Riverside County	Private	developed (Glenn Lukos Associates 2003; Wegscheider 2003, 2004)			Xh	
Temecula Education Complex++	Riverside County	City of Temecula	developed (Western Riverside County Regional Conservation Authority 2006)			Xh	
French Valley Towne Center++ (Spencer's Crossing)	Riverside County	Private	developed			Xh	
Garbani Pool++	Riverside County	Private	developed (Michael Brandman Associates 2006)			Xh	
Warm Springs++	Riverside County	Private	not preserved	development	conservation; restoration; management	X	
AA1 east (known at listing)	MCAS Miramar, San Diego County	U.S. Marine Corps	covered by MCAS Miramar INRMP (Ogden 1994)	nonnative plants; fire control; military activities	conservation; restoration; management	X	F
AA1 south	MCAS Miramar, San Diego County	U.S. Marine Corps	covered by MCAS Miramar INRMP; DOD MA 1; restored; mitigation site (Black 2007; Service 1992)	nonnative plants; fire control; military activities	conservation; restoration; management	X	F

Appendix 1. Vernal pool complexes identified as occupied at listing of Riverside fairy shrimp in 1993 (58 FR 41384) and since listing

Complex Name	Location	Owner	Status	Major Threats	Needs	RSF	Recovery Plan Appendices
Ramona, T (T Ramona in Appendix G)	City of Ramona, San Diego County (at the Ramona Airport)	County of San Diego	partially impacted by airport maintenance; partially restored; conserved (Robert MacAller, Principal, RECON, pers. comm., 2007; Service 1998b, 2001c)	nonnative plants; emergency response	restoration; management	X	F and G
Cockleburr Mesa	MCB Camp Pendleton, San Diego County	U.S. Marine Corps	covered by MCB Camp Pendleton INRMP (MCB Camp Pendleton 2007)	military activities; nonnative plants; fire control	conservation; restoration; management	X	F
Las Pulgas (RECON 2001b)	MCB Camp Pendleton, San Diego County	U.S. Marine Corps	covered by MCB Camp Pendleton INRMP; some pools lost/ impacted by Base development and other activities covered by section 7 consultations (MCB Camp Pendleton 2007; Service 1996b, 2000c, 2003b, c, 2005b, c)	military activities; nonnative plants; fire control	conservation; restoration; management	X	F
O'Neill	MCB Camp Pendleton, San Diego County	U.S. Marine Corps	covered by MCB Camp Pendleton INRMP (MCB Camp Pendleton 2007)	military activities; nonnative plants; fire control	conservation; restoration; management	X	G
San Mateo	MCB Camp Pendleton, San Diego County	U.S. Marine Corps	covered by MCB Camp Pendleton INRMP; some pools lost to Base development covered by section 7 consultations (MCB Camp Pendleton 2007; Service 1996b)	military activities; nonnative plants; fire control	conservation; restoration; management	X	F

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Complex Name	Location	Owner	Status	Major Threats	Needs	RSF	Recovery Plan Appendices
Papa Three++	MCB Camp Pendleton, San Diego County	U.S. Marine Corps	covered by MCB Camp Pendleton INRMP; impacts authorized (Service 2005d) but have not yet taken place (SAIC 2004; MCB Camp Pendleton 2005, 2007)	military activities; nonnative plants; fire control; <i>B. lindahli</i>	conservation; restoration; management	X	
State Park Lease Area	MCB Camp Pendleton, San Diego County	U.S. Marine Corps	covered by MCB Camp Pendleton INRMP (MCB Camp Pendleton 2007)	nonnative plants	conservation; restoration; management	X	F
Stuart Mesa	MCB Camp Pendleton, San Diego County	U.S. Marine Corps	covered by MCB Camp Pendleton INRMP; 1 pool lost to development activities covered by section 7 consultations (MCB Camp Pendleton 2007; Service 2004b)	military activities; nonnative plants; fire control	conservation; restoration; management	X	F
Wire Mountain (Y1-6)	MCB Camp Pendleton, San Diego County	U.S. Marine Corps	covered by MCB Camp Pendleton INRMP; 4 pools lost (filled and disced) (unauthorized); loss offset via restoration (MCB Camp Pendleton 2007)	military activities; nonnative plants; fire control	conservation; restoration; management	X	F
JJ2 (Poinsettia Train Station; Water's End/ Dunn/ Poinsettia Shores)	City of Carlsbad, San Diego County (at the Poinsettia Train Station/Shores in Carlsbad)	North County Transit District; Private	impacted by construction at train station; partially restored; conserved (Dudek and Associates 1998)	nonnative plants; fragmentation	restoration; management	X	F

Appendix 1. Vernal pool complexes identified as occupied at listing of Riverside fairy shrimp in 1993 (58 FR 41384) and since listing

Complex Name	Location	Owner	Status	Major Threats	Needs	RSF	Recovery Plan Appendices
J1 (Calterracas)	Otay Mesa, City of San Diego, San Diego County	Private	developed (Service 1997; RECON 1997)			Xh	
J4-7 (Robinhood Ridge, not including mitigation pools; J7 portion of complex extirpated by development)	Otay Mesa, City of San Diego, San Diego County	Private	partially developed, remainder conserved; restored to offset development (Helix 1997; Service 1998c)	nonnative plants; fragmentation	management	X	F
J2 (including J2W, J2N, J2S in Bauder 1986 and City of San Diego 2004) (not including mitigation pools)	Otay Mesa, City of San Diego, San Diego County	J2N- Wall/Hudson Caltrans; J2S and W-Private and City of San Diego	partially developed, remainder conserved; restored (RECON 1997; Service 1997, 2004c, e)	nonnative plants; fragmentation	management	X	F
J14 (Anderson/SR 905)	Otay Mesa, City of San Diego, San Diego County	Private	proposed (partial development partial conservation?) - State Route 905 (Helix 2006; Service 2004c)	development; fragmentation; OHV; nonnative plants	conservation; restoration; management	X	F
J14++ (Recon South)	Otay Mesa, City of San Diego, San Diego County	Private	conserved (RECON 1997)		management	X	
J15 (Arnie's Point)	Otay Mesa, City of San Diego, San Diego County	Department of Homeland Security	partially developed, remainder conserved; restored (Helix 2005a; Service 2002b)	nonnative plants	management	X	F

Appendix 1. Vernal pool complexes identified as occupied at listing of Riverside fairy shrimp in 1993 (58 FR 41384) and since listing

Complex Name	Location	Owner	Status	Major Threats	Needs	RSF	Recovery Plan Appendices
J22 (Sunroad Centrum)	Otay Mesa, City of San Diego, San Diego County	Private	proposed development; assumed present for a section 7 consultation (Service 2003d)	development; fragmentation; OHV; nonnative plants	conservation; restoration; management	X	G
J29-30 (Lonestar/ McMillan/ New Millennium) (known at listing)	Otay Mesa, City of San Diego, San Diego County	Otay Ranch	proposed development (Helix 2003, 2006b; City of San Diego 2004, 2006)	development; fragmentation; OHV; nonnative plants	conservation; restoration; management	X	F
J32++ (West Otay A+B) (mitigation site)	Otay Mesa	TET	TET informal mitigation bank; conserved (City of San Diego 2004)	OHV; nonnative plants	restoration; management	X	
J3	Otay Mesa, City of San Diego, San Diego County	Private/Caltrans /Sweetwater Union High School	partially developed; remainder not preserved; proposed development; SR 905 (Helix 2002b; Service 2000d, 2004c)	development; fragmentation; OHV; nonnative plants	conservation; restoration; management	X	G
J33++ Sweetwater High School	Otay Mesa, City of San Diego, San Diego County	Private/ Sweetwater Union High School	conserved; mitigation site (Service 2000d)	nonnative plants	management	X+	
J34 ++ (Candlelight)	Otay Mesa, City of San Diego, San Diego County	Private	proposed development (Helix 2004a, b)	development; fragmentation; OHV; nonnative plants	conservation; restoration; management	X	
J2W++ (St. Jeromes Church/ Clayton)	Otay Mesa, City of San Diego, San Diego County	Private	proposed development (Dudek and Associates 2001b)	development; fragmentation; OHV; nonnative plants	conservation; restoration; management	X	

Appendix 1. Vernal pool complexes identified as occupied at listing of Riverside fairy shrimp in 1993 (58 FR 41384) and since listing

Complex Name	Location	Owner	Status	Major Threats	Needs	RSF	Recovery Plan Appendices
J35++ (Brown Field)	Otay Mesa, City of San Diego, San Diego County	City of San Diego	not preserved (Helix 1998; Service 1999b)	development; fragmentation; nonnative plant; emergency response	conservation; restoration; management	X	
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 (RECON 2001a; Helix 2005b; URS 2005; Service 2003e) (Pool 121 in Recon, Pool 97 in Helix, and Pool 32 in URS; assumed to be same pool)	development; fragmentation; OHV; nonnative plants	conservation; restoration; management	X	
Tejera Rejada Preserve (in Appendix F only) (Carlsberg Complex in Recovery Plan)	City of Moorpark, Ventura County	Public – Mountains Recreation and Conservation Authority	impacted watershed; conserved; wet season surveys conducted each season between 2002 and 2006 failed to locate any adults (Mountains Recreation and Conservation Authority 2006)	nonnative plants, altered hydrology, fragmentation	continued monitoring, restoration, management	unknown	F
LA Airport++	City of Los Angeles, Los Angeles County	City of Los Angeles	developed (RECON 1998c; Service 2005a, 2007a)			Xh	

F = listed in Appendix F of Recovery Plan

G = listed in Appendix G of Recovery Plan

Xh=extirpated

++ = complex/occurrence found since Recovery Plan

DOD = U.S. Department of Defense

CDFG = California Department of Fish and Game

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	Riverside fairy shrimp	Recovery Plan Appendices
Ellwood Mesa (Sterling Preserve)	Santa Barbara	Public – City of Goleta	conserved	nonnative plants, edge effects	?	NP	G
Isla Vista-Del Sol	City of Santa Barbara, Santa Barbara County	City of Santa Barbara	mitigation	nonnative plants	management	NP	G
More Mesa	Santa Barbara	Public (County of Santa Barbara); and Private	?	development	native grasslands restoration (ongoing)	NP	G
Fairview Park	City of Costa Mesa, Orange County	City of Costa Mesa	conserved; mitigation	nonnative plants; fragmentation	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
Hemet/ Salt Creek	Riverside	Private/Public	have been surveyed and are negative for RFS			NP	F
Temecula	Riverside	?	?		?	NP	F

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	Riverside fairy shrimp	Recovery Plan Appendices
Santa Rosa Plateau	Riverside County	The Nature Conservancy	conserved			NP	F
H (undescribed) in Appendix G only	Del Mar Mesa	?	?	?		NP	G
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
H4-10 (Del Mar Mesa)	Del Mar Mesa, City of San Diego, San Diego County	CDFG - SR 52 mitigation; Service	conserved; mitigation; NWR	nonnative plants; OHV; fire control	restoration; management	NP	F
H13-15 (Del Mar Mesa)	Del Mar Mesa, City of San Diego, San Diego County	CDFG - SR 52 mitigation	conserved; mitigation; NWR	nonnative plants; OHV; fire control	restoration; management	NP	F
H18-23	Del Mar Mesa, City of San Diego, San Diego County	CDFG - SR 52 mitigation; Service	conserved; mitigation; NWR	nonnative plants; OHV; fire control	management	NP	F
H24-26(Rhodes, portion of Del Mar Mesa)	Del Mar Mesa, City of San Diego, San Diego County	Private	proposed development	development; fragmentation; OHV; nonnative plants	conservation; restoration; management	NP	G

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	Riverside fairy shrimp	Recovery Plan Appendices
H33	Del Mar Mesa, City of San Diego, San Diego County	San Diego Gas and Electric	conserved	nonnative plants; OHV; fire control	restoration; management	NP	F
BB/BB2 (New Century Center in Appendix G only)/(General Dynamics)	Kearny Mesa, City of San Diego, San Diego County	Private	developed			NP	G
G1 (Murphy Canyon)	Kearny Mesa, City of San Diego, San Diego County	U.S. Navy	DOD partially restored; mitigation	nonnative plants; OHV; fire control	management	NP	F
G2 (Murphy Canyon)	Kearny Mesa, City of San Diego, San Diego County	U.S. Navy	DOD partially restored; mitigation	nonnative plants; OHV; fire control	management	NP	F
I1 (Arjons)	Kearny Mesa, City of San Diego, San Diego County	Private; City of San Diego easement	conserved; illegally impacted	nonnative plants; fragmentation; OHV; nonnative plants	restoration; management	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 (Service 1998a).

Complex Name	Location	Owner	Status	Major Threats	Needs	Riverside fairy shrimp	Recovery Plan Appendices
I6c (Bob Baker 2)	Kearny Mesa	Private - City easement	mitigation		conservatio; restoration; management	NP	G
N1-4, 6 (Montgomery Field)	Kearny Mesa, City of San Diego, San Diego County	City of San Diego	partially developed	development; nonnative plants; emergency response	preservation; restoration; management	NP	F
U15 (Sander)	Kearny Mesa, City of San Diego, San Diego County	City of San Diego	not preserved	development; fragmentation	conservation; restoration; management	NP	G
U15 (Miramar)	MCAS Miramar, San Diego County	U.S. Marine Corps	mitigation- restored	nonnative plants; fragmentation	conservation; management	NP	G
X5 (Nobel Drive)	Kearny Mesa, City of San Diego, San Diego County	City of San Diego	conserved	nonnative plants; fragmentation	restoration; management	NP	F
Chollas Heights	City of San Diego, San Diego County	U.S. Navy	DOD partially developed, remainder restored; mitigation	nonnative plants; OHV; fire control	management	NP	F
B2 (unsure of location)	Mira Mesa, City of San Diego, San Diego County	Private	developed?			NP	F

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	Riverside fairy shrimp	Recovery Plan Appendices
B11 (Mesa Norte)	Mira Mesa, City of San Diego, San Diego County	Private	Conserved; restored; mitigation	nonnative plants; fragmentation	management	NP	F
B5 (Lopez Ridge)	Mira Mesa, City of San Diego, San Diego County	City of San Diego	conserved; mitigation	nonnative plants; fire control	restoration; management	NP	F
B6 (Tierra Alta)	Mira Mesa, City of San Diego, San Diego County	City of San Diego	conserved; mitigation	nonnative plants; fire control	restoration; management	NP	F
B7-8E (Brown Parcel)	Mira Mesa, City of San Diego, San Diego County	City of San Diego	conserved; mitigation	nonnative plants; fire control	restoration; management	NP	F
B7-8W (Crescent Heights)	Mira Mesa, City of San Diego, San Diego County	Private	proposed development	development; fragmentation	conservation; restoration; management	NP	F
C10-16,26 (Winterwood Park)	Mira Mesa, City of San Diego, San Diego County	City of San Diego	partially illegally impacted; proposed mitigation site	fragmentation; OHV; nonnative plants	conservation; restoration; management	NP	F

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	Riverside fairy shrimp	Recovery Plan Appendices
Maddox Park (C28 in City of San Diego 2004)	Mira Mesa, City of San Diego, San Diego County	San Diego Unified School District	proposed development	development; fragmentation; OHV; nonnative plants	conservation; restoration; management	NP	G
D1 (Fenton Mira Mesa Sandmine)	Mira Mesa	Private	impacted; filled			NP	G
D5-6 (D5-8 in Appendix F and Carrol Canyon/Parkdale Carroll Canyon in City of San Diego 2004)	Mira Mesa, City of San Diego, San Diego County	City of San Diego	119 pools conserved; managed as mitigation for 1-1-82-F-108; 4 pools not preserved	development; nonnative plants; fragmentation; OHV; nonnative plants	conservation; restoration; management of 4 vps	NP	F
I7 - Eastgate Mall/Miramar Industrial	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1; Restored	nonnative plants; fragmentation	conservation; restoration; management	NP	F
A4, Tierrasanta	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1	nonnative plants; fire control; military activities	conservation; restoration; management	NP	F
AA1 west	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1	nonnative plants; fire control; military activities	conservation; restoration; management	NP	F
AA10	MCAS Miramar, San Diego County	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 (Service 1998a).

Complex Name	Location	Owner	Status	Major Threats	Needs	Riverside fairy shrimp	Recovery Plan Appendices
AA11	Miramar	U.S. Marine Corps	DOD MA 1	nonnative plants; fire control; military activities	conservation; 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 north+	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 5	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
AA13	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1	nonnative plants; fire control; military activities	conservation; restoration; management	NP	F
AA2 (Not in Appendix E of Recovery Plan, but 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
AA3	MCAS Miramar, San Diego County	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 (Service 1998a).

Complex Name	Location	Owner	Status	Major Threats	Needs	Riverside fairy shrimp	Recovery Plan Appendices
AA4-7	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1; mitigation	nonnative plants; fire control; military activities	conservation; restoration; management	NP	F
AA8	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1	nonnative plants; fire control; military activities	conservation; restoration; management	NP	G
AA9	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1	nonnative plants; fire control; military activities	conservation; restoration; management	NP	F
EE1	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA	nonnative plants; fire control; military activities	conservation; restoration; management	NP	F
EE2	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1; partially developed; restored	nonnative plants; fire control; military activities	conservation; restoration; management	NP	F
F north (F1-27 in Appendix F)	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1; partially developed; mitigation	nonnative plants; fire control; military activities	conservation; restoration; management	NP	F
F28 (Appendix G only)	Miramar	U.S. Marine Corps	See complex F (north)			NP	G

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	Riverside fairy shrimp	Recovery Plan Appendices
FF1-2	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 4; Partially developed	nonnative plants; fire control; military activities	conservation; restoration; management	NP	G
GA	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1	nonnative plants; fire control; military activities	conservation; restoration; management	NP	G
GG1	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1; Partially developed	nonnative plants; fire control; military activities	conservation; restoration; management	NP	G
GG2+	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1; Partially developed	nonnative plants; fire control; military activities	conservation; restoration; management	NP	G
GG3+	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 3; Partially developed	nonnative plants; fire control; military activities	conservation; restoration; management	NP	G
HH1+	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1; restoration site	nonnative plants; fire control; military activities	conservation; restoration; management	NP	F
HH2+	MCAS Miramar, San Diego County	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 (Service 1998a).

Complex Name	Location	Owner	Status	Major Threats	Needs	Riverside fairy shrimp	Recovery Plan Appendices
HH3+	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 2; partially developed; partially restored (80% filled, 20% restored)	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
RR1	Miramar	U.S. Marine Corps	DOD MA 1	nonnative plants; fire control; military activities	conservation; restoration; management	NP	F
RR2	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1	nonnative plants; fire control; military activities	conservation; restoration; management	NP	F
U North (U1-13 Landmark/U-North in Appendix F)	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1; partial restoration site	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 (Service 1998a).

Complex Name	Location	Owner	Status	Major Threats	Needs	Riverside fairy shrimp	Recovery Plan Appendices
U19 (Cubic)	MCAS Miramar, San Diego County	Private; U.S. Marine Corps	private; partially restored	development; fragmentation; nonnative plants; fire control	conservation; restoration; management on private-management on restoration site	NP	G
V (V 1-4 Sim J. Harris in Appendix F?)	Miramar	U.S. Marine Corps	DOD MA 1			NP	F
W1-2	Miramar	U.S. Marine Corps	DOD MA 1			NP	F
W4	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1; partially developed	nonnative plants; fire control; military activities		NP	F
W3	Miramar	U.S. Marine Corps	DOD MA 1			NP	F
X1-4 (West Miramar)	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1; mitigation site	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 (Service 1998a).

Complex Name	Location	Owner	Status	Major Threats	Needs	Riverside fairy shrimp	Recovery Plan Appendices
Z10	MCAS Miramar, San Diego County	U.S. Marine Corps	MA 5; partially developed; partially restored (90%filled,10% restored)	nonnative plants; fire control; military activities		NP	F
Z1-3	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 1	nonnative plants; fire control; military activities		NP	F
Z6-7	MCAS Miramar, San Diego County	U.S. Marine Corps	DOD MA 5; partially developed; partially restored 10% filled, 90% restored	nonnative plants; fire control; military activities		NP	F
Highland Valley (oak Country?)	Ramona	Private	not preserved	development	conservation; restoration; management	NP	F
Hwy 67 & Kalbaugh area	City of Ramona, San Diego County	Private	not preserved	development; fragmentation; OHV; nonnative plants	conservation; restoration; management	NP	F
Main Street	Ramona	Private	not preserved	development	conservation; restoration; management	NP	F

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	Riverside fairy shrimp	Recovery Plan Appendices
Montecito Road (on Monticito Ranch property?)	City of Ramona, San Diego County	Private	not preserved; illegal clearing	development; fragmentation; OHV; nonnative plants	conservation; restoration; management	NP	F
Ramona High School	City of Ramona, San Diego County	Ramona School District	illegally impacted; proposed development	development; fragmentation; OHV; nonnative plants	conservation; restoration; management	NP	F
Ta, Hwy 67 & 15th (SE) (Ramona Post Office)	City of Ramona, San Diego County	U.S. Postal Service	impacted			NP	F
Tb, Hwy 67 & Hunter (SE)	City of Ramona, San Diego County	Private	not preserved	development; fragmentation; OHV; nonnative plants	conservation; restoration; management	NP	F
Tc, La Brea & Kalbaugh (SE)	City of Ramona, San Diego County	Private	conserved as mitigation for post office	nonnative plants; fragmentation; OHV; nonnative plants	management	NP	F
L11-13 (Fry's Bent Ave)	City of San Marcos, San Diego County	Private	conserved; mitigation	nonnative plants; fragmentation	restoration; management	NP	F
L14+ Grand/Pacific	San Marcos	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 (Service 1998a).

Complex Name	Location	Owner	Status	Major Threats	Needs	Riverside fairy shrimp	Recovery Plan Appendices
L15+ Armolite North/Copley Property	City of San Marcos, San Diego County	Private	proposed development	development; fragmentation; OHV; nonnative plants	conservation; restoration; management	NP	G
L1-6 (Upham)	City of San Marcos, San Diego County	Private	partially developed	development; fragmentation; OHV; nonnative plants	conservation; management of remaining pools	NP	F
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

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	Riverside fairy shrimp	Recovery Plan Appendices
L9-10 (Superior Ready Mix, Universal Boot)	City of San Marcos, San Diego County	Private; City of San Marcos	proposed development	development; fragmentation; OHV; nonnative plants	conservation; restoration; management	NP	F
Basilone	Camp Pendleton	U.S. Marine Corps	DOD			NP	G
JJ1 (Palomar Point/ Hieatt/ Jett) & (San Diego County Airport)	Carlsbad	Palomar Point; Hieatt; Jett; San Diego County	partially impacted; partially restored; conserved mitigation	nonnative plants; fragmentation	easement; management	NP	F
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	conservation; restoration; management	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

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	Riverside fairy shrimp	Recovery Plan Appendices
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
K6	Otay lakes	Private	proposed development	development	conservation; restoration; management	NP	G
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
J11E	Otay Mesa, City of San Diego, San Diego County	Private	not preserved	development; fragmentation; OHV; nonnative plants	conservation; restoration; management	NP	F
J11W	Otay Mesa, City of San Diego, San Diego County	Private	not preserved	development; fragmentation; OHV; nonnative plants	conservation; restoration; management	NP	F
J12	Otay Mesa	Private	not preserved	development	conservation; restoration; management	NP	F

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	Riverside fairy shrimp	Recovery Plan Appendices
J13E	Otay Mesa	Private	not preserved	development	conservation; restoration; management	NP	F
J13N	Otay Mesa, City of San Diego, San Diego County	Private	proposed development	development; fragmentation; OHV; nonnative plants	conservation; restoration; management	NP	F
J13S	Otay Mesa, City of San Diego, San Diego County	Private	not preserved	development; fragmentation; OHV; nonnative plants	conservation; restoration; management	NP	F
J16-17 (Goat Mesa/Wruck Canyon)	Otay Mesa, City of San Diego, San Diego County	City of San Diego	conserved	nonnative plants; OHV	restoration; management	NP	F
J18 (Goat Mesa/Wruck Canyon)	Otay Mesa	City of San Diego	conserved	nonnative plants; Border Patrol activities	restoration; management	NP	F
J19	Otay Mesa	Private	agriculture	agriculture; development; Border Patrol activities	conservation; restoration; management	NP	F
J20	Otay Mesa	Private	agriculture	agriculture; development; Border Patrol activities	conservation; restoration; management	NP	F
J21	Otay Mesa	Private - drainage issues	agriculture; border fence	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 (Service 1998a).

Complex Name	Location	Owner	Status	Major Threats	Needs	Riverside fairy shrimp	Recovery Plan Appendices
J23-24	Otay Mesa	County of San Diego	not preserved	development	conservation; management	NP	F
J25	Otay Mesa, City of San Diego, San Diego County	County of San Diego	not preserved	development; OHV; nonnative plants	conservation; management	NP	F
J26 (Upham)	Otay Mesa, City of San Diego, San Diego County	Private	partially restored; conserved	development; nonnative plants; OHV; fire control	management	NP	F
J27	Otay Mesa	Private - Empire Center	partially impacted; partially restored; conserved	nonnative plants; fragmentation	conservation; restoration; management	NP	F
J28E	Otay Mesa, City of San Diego, San Diego County	Private	proposed development	development; fragmentation; OHV; nonnative plants	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

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	Riverside fairy shrimp	Recovery Plan Appendices
R4+	Proctor Valley	Private	?		?	NP	F
S1-3	Sweetwater Reservoir, Unincorporated San Diego County	Sweetwater Authority; Service	Conserved; NWR	nonnative plants; fire control	restoration; management	NP	F
Tijuana Estuary (in Appendix G only)	Tijuana Slough	U.S. Fish and Wildlife Service	conserved	nonnative plants	management	NP	G
Cruzan Mesa	Unincorporated Los Angeles County	Private	conserved – Santa Monica Mountains Conservancy	edge effects	continued monitoring	NP	F
Isla Vista-Camino Corto	Santa Barbara	County of Santa Barbra	?		?	NP	G
Isla Vista-del Playa	Santa Barbara		?		?	NP	G

F = listed in Appendix F of Recovery Plan

G = listed in Appendix G of Recovery Plan

Xh=extirpated

++ = complex/occurrence found since Recovery Plan

NP=Not currently know to be occupied

DOD = U.S. Department of Defense

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

CDFG = California Department of Fish and Game

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

Riverside fairy shrimp (*Streptocephalus woottoni*)

Current Classification: Endangered

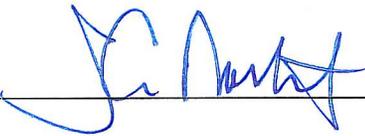
Recommendation Resulting from the 5-Year Review:

- 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