

**Salt marsh harvest mouse  
(*Reithrodontomys raviventris*)**

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

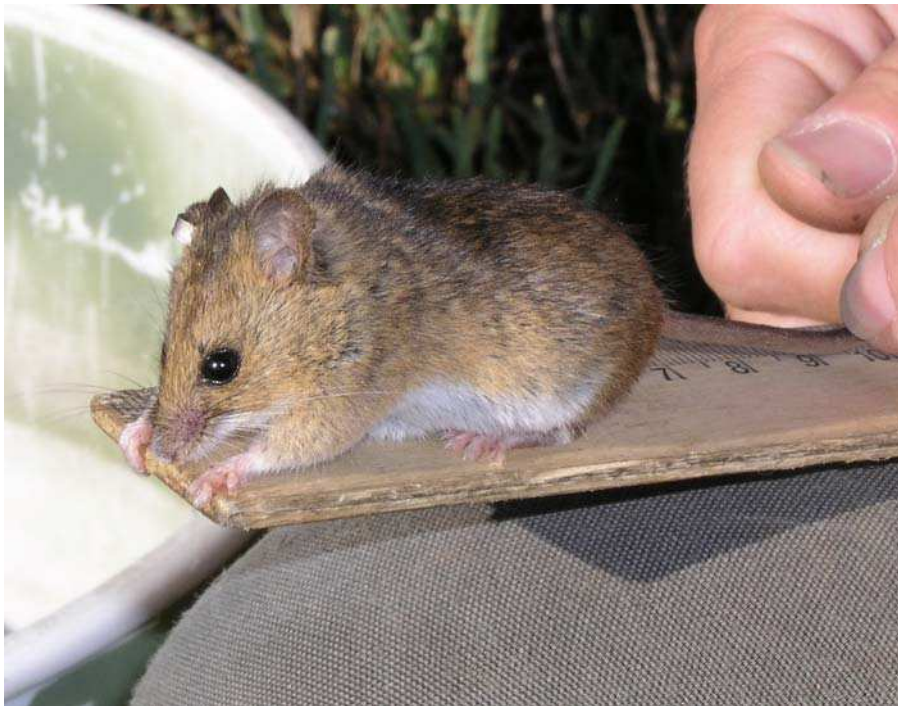


Photo by Valary Bloom, USFWS

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

**February 2010**

## 5-YEAR REVIEW

Salt marsh harvest mouse (*Reithrodontomys raviventris*)

### 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. The salt marsh harvest mouse was listed as endangered under the Endangered Species Preservation Act in 1970, so was not subject to the current listing processes and, therefore, did not include an analysis of threats to the salt marsh harvest mouse. In this 5-year review, we will consider listing of this species as endangered or threatened 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 this species. We will consider the best available scientific and commercial data on the species, and focus on new information available since the species was listed. 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 salt marsh harvest mouse (*Reithrodontomys raviventris*) is a rodent in the family Muridae (subfamily Sigmodontinae). As described in the *Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* (Draft Recovery Plan) (Service 2010), there are two subspecies of salt marsh harvest mice: the northern salt marsh harvest mouse (*Reithrodontomys raviventris halicoetes*) lives in the marshes of the San Pablo and Suisun Bays, and the salt marsh harvest mouse (*Reithrodontomys raviventris raviventris*) is found in the marshes of Corte Madera, Richmond, and South San Francisco Bay. This species is generally restricted to saline (salty) or brackish (somewhat salty) marsh habitats around the San Francisco Bay Estuary, and is found in mixed saline/brackish areas in the Suisun Bay area and has been found in one brackish area in the southern South San Francisco Bay (H. T. Harvey and Associates 2006). Habitat loss due to human actions is the greatest threat to the salt marsh harvest mouse. Habitat loss that threatens the salt marsh harvest mouse is due to filling, diking, subsidence, changes in water salinity, non-native species invasions, sea level rise associated with global climate change and pollution. In addition, habitat suitability of many marshes is further limited by small size, fragmentation, and lack of other vital features such as sufficient escape habitat. Larger tracts of high quality habitat are needed to maintain stable populations over time. Both subspecies of salt marsh harvest mouse

have grooved upper front teeth (the scientific name *Reithrodontomys raviventris* means “grooved-toothed mouse with a red belly”), but only a few populations of the southern subspecies have animals with a cinnamon- or rufous-colored belly. Both subspecies have rich dorsal brown hair and a unicolored to moderately bicolored tail. The combined head and body length is approximately 7.6 centimeters (3 inches) with an average weight of less than 10 grams (0.353 ounce).

### **Methodology Used to Complete This Review:**

This review was prepared by the Sacramento Fish and Wildlife Office (SFWO), following the Region 8 guidance issued in March 2008. We used information from the Draft Recovery Plan, survey information from experts who have been monitoring various localities of this species, and the California Natural Diversity Database (CNDDDB 2009) maintained by the California Department of Fish and Game (CDFG). The Draft Recovery Plan and personal communications with experts were our primary sources of information used to update the species’ status and threats. This 5-year review contains updated information on the species’ biology and threats, and an assessment of that information compared to that known at the time of listing. We focus on current threats to the species that are categorized by the Act’s five listing factors. The review synthesizes all this information to evaluate the listing status of the species and provide an indication of its progress towards recovery. Finally, based on this synthesis and the threats identified in the five-factor analysis, we recommend a prioritized list of conservation actions to be completed or initiated within the next 5 years.

### **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 5, 2008 (Service 2008). We received two comment letters in response to the Federal Register Notice initiating this 5-year review. One comment letter was from the California Attorney General and the second was from the Center for Biological Diversity. The issues discussed there are addressed under the appropriate section below.

## **Listing History:**

### Original Listing

FR Notice: 35 FR 16047

Date of Final Listing Rule: October 13, 1970

Entity Listed: Salt marsh harvest mouse (*Reithrodontomys raviventris*), a mammal species

Classification: Endangered

### State Listing

The salt marsh harvest mouse (*Reithrodontomys raviventris*) was listed by the State of California as endangered in 1971 and it is a CDFG Fully Protected Species.

**Associated Rulemakings:** No critical habitat has been designated for the salt marsh harvest mouse.

**Review History:** No formal status review has been conducted since the species was listed in 1970.

**Species' Recovery Priority Number at Start of 5-Year Review:** The recovery priority number is based on a 1-18 ranking system where 1 is the highest-ranked recovery priority and 18 is the lowest (Service 1983). The recovery priority number for the salt marsh harvest mouse is 2C according to the Service's 2009 Recovery Data Call for the Sacramento Fish and Wildlife Office. The priority number of 2C is based on a high degree of threat, a high potential of recovery, and its taxonomic standing as a species. The additional "C" ranking indicates some degree of conflict between the conservation needs of the species and economic development (Service 1983).

## **Recovery Plan or Outline**

**Name of Plan:** Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California

**Date Issued:** January 2010

**Dates of Previous Revisions:** Salt Marsh Harvest Mouse and California Clapper Rail Recovery Plan was written for the species in 1984 (Service 1984).

## **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. The 1996 Policy Regarding the Recognition of Distinct Vertebrate Population Segments under the Endangered Species

Act (61 FR 4722, February 7, 1996) clarifies the interpretation of the phrase “distinct population segment” for the purposes of listing, delisting, and reclassifying species under the Act.

The salt marsh harvest mouse is a vertebrate that is not listed as a DPS. No relevant new information regarding the application of the DPS policy to the salt marsh harvest mouse is under review. Because the DPS policy is not applicable to the salt marsh harvest mouse, 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 Biology and Life History

*Reproduction.* Male salt marsh harvest mice are generally sexually active from April through September, while the female breeding season extends from March through November for the northern subspecies, and May through November for the southern subspecies (Fisler 1965). Bias and Morrison (1993) suggest that the breeding season of the Mare Island population (northern subspecies) extends from August through November; more than 30 percent of the females trapped were pregnant during September and October. Compared with environmentally determined mortality factors, reproduction does not appear to be a limiting factor for the species.

*Home range.* Telemetry studies of the northern salt marsh harvest mouse at Mare Island Marshes found a mean home range size of 0.21 hectare (0.52 acre), and a mean linear distance moved of 11.9 meters (39 feet) in 2 hours (Bias and Morrison 1999). Most movements occurred in June, and fewest movements occurred in November. Mare Island mean home ranges were much larger than those estimated by Geissel *et al.* (1988) for the southern subspecies, which were no greater than 0.15 hectare (0.37 acre). Due to different measuring techniques, no comparison between the subspecies regarding mean linear distance traveled can be made. Bias and Morrison (1993, 1999) found that movements through open habitats were not restricted to rare or extraordinary events, however, Shellhammer (Shellhammer, *in litt.* 2009) identified that generally mice do not cross large areas of open habitats, assuming that “open habitats” mean “open space” or unvegetated habitat.

*Competition.* Population dynamics based on interactions between harvest mice and other small mammals are not well understood (Blaustein 1980; Geissel *et al.* 1988; Bias and Morrison 1993; Bias 1994; Hulst 2000). Hypotheses of competitive exclusion in salt marsh harvest mouse populations, based on analogy with studies on voles (*Microtus californicus*) and western harvest mice (*Reithrodontomys megalotis*), should be applied with caution to salt marsh harvest mice (Blaustein 1980; 1981; Heske *et al.* 1984).

### Spatial Distribution and Abundance

*Historical distribution.* By the time the salt marsh harvest mouse was distinguished as a species in 1908, extensive tidal marshes throughout its range had already been reclaimed for agriculture, salt ponds, and urban development. Therefore, there are no historical records of its abundance or

distribution in the estuary before 1908 to use as a baseline. In fact, even surveys conducted since the time of listing were site specific in nature and in no way representative of the species abundance rangewide. However, at the time of listing, it is likely that populations of the species rangewide had fallen to low levels.

The salt marsh harvest mouse probably occupied most of the middle tidal, or *Sarcocornia*- (pickleweed-) dominated, marsh plains and high marsh zones of San Francisco Bay, San Pablo Bay, and the Suisun Marsh prior to the significant marsh reclamation of the 1840s. Although estimates of historic tidal marsh area in the San Francisco Bay Estuary are not precise enough to distinguish between suitable and unsuitable habitats for the salt marsh harvest mouse, most of the mature tidal marshes in the region had extensive middle marsh plains and even more extensive high marshes. It is likely that most suitable habitat supported salt marsh harvest mice, since the species can colonize rapidly under favorable conditions (Geissel *et al.* 1988; Bias and Morrison 1999), and habitats were naturally contiguous and extensive. Thus, the area inhabited by the salt marsh harvest mouse prior to tidal marsh reclamation could have approached 77,000 hectares (190,000 acres), the total tidal marsh area (Dedrick 1989; Goals Project 1999).

*Current distribution.* The current known distribution (surveyed locations) of the salt marsh harvest mouse can be found in Figure 1 (California Natural Diversity Database 2009). Staff from CDFG are currently working with their vegetation group and will have all of the potential habitat in Suisun Marsh mapped soon (Barthman-Thompson, *in litt.* 2009). In general, distribution can be estimated from the remaining suitable diked and tidal marsh habitat, and the review of live-trapping surveys, although trapping data are limited (Zetterquist 1976; Larkin 1984; Shellhammer 1984; Bias and Morrison 1993). Much of the data on local abundance and distribution of the salt marsh harvest mouse have been derived from local short-term studies, usually conducted on privately owned diked baylands proposed for land use changes (Shellhammer, pers. comm. 2005). These data must be interpreted with caution as data become quickly outdated.

*Southern subspecies population trends.* The population status of the southern subspecies is more precarious than that of the northern subspecies. Few major, resilient, or secure populations persist (Roberts Landing, Hayward Marsh, Baumberg, Mayhews Landing, Calaveras Point Marsh, New Chicago Marsh, Renzel/ITT Marsh, Redwood Shores, in addition to likely populations at Bair Island, Greco Island, Mowry Slough, and other sites) (Shellhammer, pers. comm. 2005). These are very small and isolated compared with the historical pattern of distribution and abundance of the subspecies. All major population centers of the southern subspecies are remote from one another based on dispersal distances known for the species. The small populations and higher degree of isolation of the southern subspecies in Marin County indicate a high probability of local extirpation due to inability to recolonize following local extinction.

Although salt marsh harvest mouse abundance does not appear to correspond with the distribution of its native tidal salt marsh due to the relatively common occurrence of the species in areas of nontidal *Sarcocornia pacifica* (pickleweed) marsh, this appears to be an artifact of surveying effort. A fairly small fraction of large pure tidal marsh has been surveyed for the species, while a large fraction of diked marshes have been surveyed. The few large tidal marshes

that have been surveyed have yielded very high densities of the mouse (Duke, pers. comm. 2005).

Studies by Shellhammer (Shellhammer, pers. comm. 2005) indicate that population size is generally correlated with the depth of the *Sarcocornia* plain (*i.e.*, the middle zone of tidal marshes). There are indications that deep (from shore to bay) *Sarcocornia* marshes, especially if they have islands of *Grindelia* within them, may provide enough habitat for the mice such that they can compensate for extremely narrow high marshes at their upper edges. Corridors (sometimes referred to as strip or narrow fringing marshes, but also can be bands of appropriate vegetation between two larger marshes) tend to have narrower *Sarcocornia* zones, as well as extremely narrow high marsh zones, and support few to no salt marsh harvest mice (Shellhammer, *in litt.* 2009). In fact, the narrower the strip marsh, the more frequently and intensely it floods (Albertson *in litt.* 2009). Most of the marshes of the South San Francisco Bay are strip-like marshes and, as such, support few harvest mice. In strip-like marshes identified as marsh corridors to connect habitat areas, the relative value of the width and complexity of the high marsh zone increases as the width of the middle marsh, or pickleweed/*Sarcocornia* zone, diminishes (Shellhammer, pers. comm. 2005).

*Northern subspecies population trends.* Though survey data is sparse, the fringing salt marshes along northern San Pablo Bay (Petaluma River to Mare Island Strait), particularly the Highway 37/Mare Island Marsh, do support fluctuating populations of salt marsh harvest mice. These include diked salt marshes south of Black John Slough (lower Petaluma River) and tidal/microtidal marshes around Gallinas Creek, Coon Island, Fagan Marsh, and Point Edith to Middle Point.

The Suisun Marsh may contain the largest population of salt marsh harvest mice in the entire remaining range. Though opportunistic and inconsistent trapping efforts occurred even earlier, standardized annual surveys have been conducted in the Suisun Marsh since 1997 by CDFG and California Department of Water Resources (DWR). These efforts continue to find high numbers in both diked and tidal wetlands. Capture efficiencies from eight separate tidal and diked locations surveyed in 2008 and 2009 were considered high, averaging 10 percent (Barthman-Thompson, *in litt.* 2009). The longest and most consistent trapping data set is for the Crescent Unit at the Grizzly Island Wildlife Area which began in 2000. Average capture efficiency over the last 12 years was approximately 11.5 percent (Barthman-Thompson, *in litt.* 2010). Fluctuations at these sentinel sites over those 12 years reflect measurable factors like changes in vegetation cover and less measurable factors such as late winter/spring rainfall which could affect reproductive success (Barthman-Thompson, *in litt.* 2010). In addition, it appears that capture efficiency is increasing which indicates that the populations may be increasing. The vegetation cover had remained stable until 2008, when an increase in dead vegetation was observed (Barthman-Thompson, *in litt.* 2010). This could be a natural change in the vegetation lifecycle and will be monitored in future years.

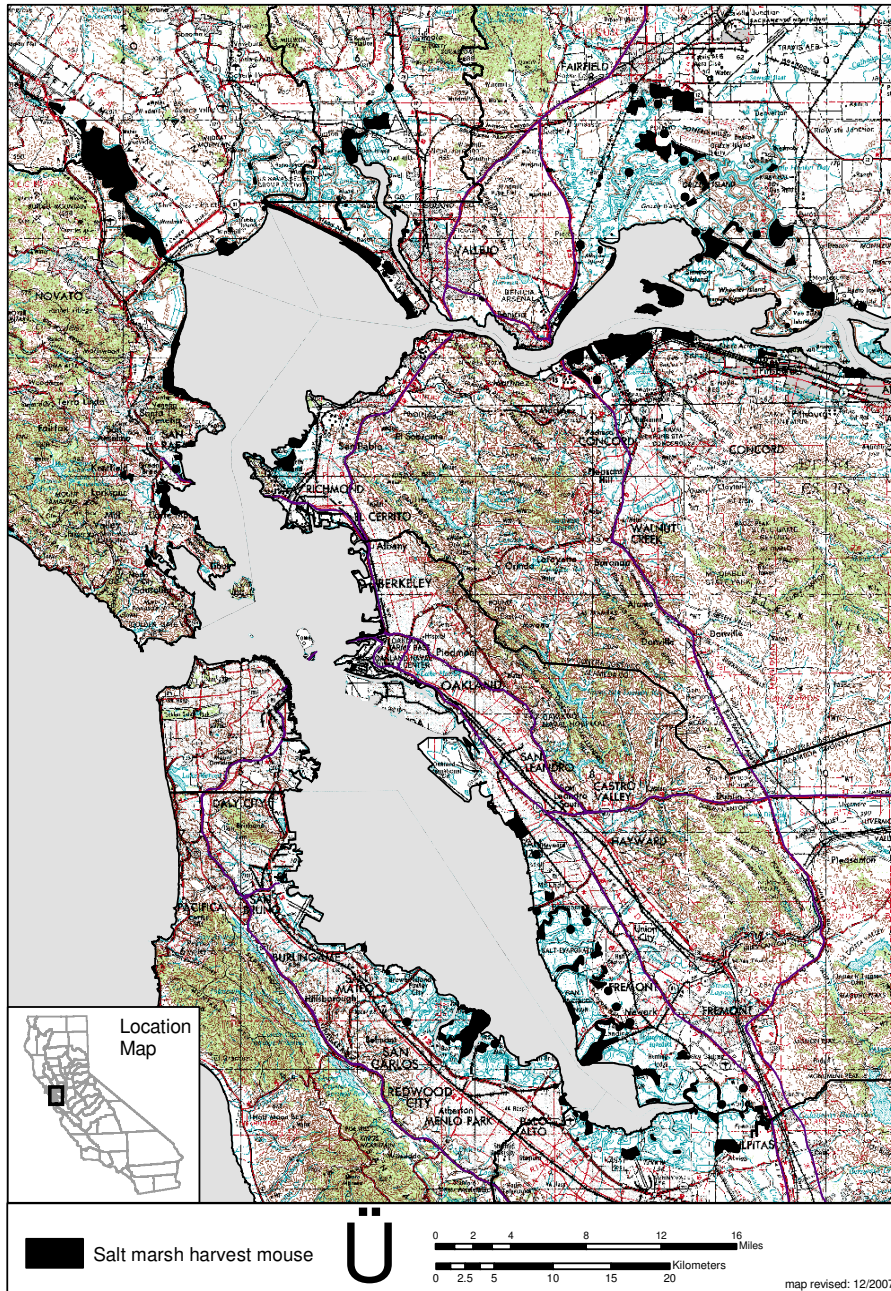
Suisun marsh trapping has indicated that salt marsh harvest mouse populations may rebound relatively quickly from depressed population levels. In winter/spring of 2006, the Crescent Unit and the Hill Slough Wildlife Area (Ponds 1 and 2), were flooded due to high tides and levee overtopping, but by 2007, salt marsh harvest mouse numbers had increased to pre-flood event

levels. Also, trapping immediately following a 2004 fire at Peytonia Slough Ecological Reserve documented salt marsh harvest mice using the burned area in low numbers. The year after the burn, salt marsh harvest mouse numbers had dramatically increased from the early post-burn trapping (Barthman-Thompson, *in litt.* 2010). It is possible that a population's ability to rebound is dependant upon extent and quality of habitat available, as well as not being concentrated during high tide events such that predation is a significant threat to survivors.

Like the southern subspecies, many northern subspecies populations have been displaced from tidal marshes to more variable diked *Sarcocornia* marshes. Most of the populations in diked managed marshes of Suisun Marsh may depend on wetland management and vegetation colonization. Salt marsh harvest mice are found in abundance in the majority of diked brackish marshes that have been surveyed. The Suisun Marsh currently contains twelve "Conservation Areas" totaling over 2,500 acres (1,012 hectares). Diked wetlands in Suisun are vulnerable to catastrophic flooding which over time can lead to local extirpation. Salt marsh harvest mice have also been found in significant numbers in grasslands at the upper edge of diked marshes around San Francisco Bay (Zetterquist 1976; Shellhammer *et al.* 1982; Johnson and Shellhammer 1988; Shellhammer *et al.* 1988) and in Suisun, as described below under Habitat/Ecosystem. The extent to which this habitat is utilized is not clear.

Less population survey information, outside of Suisun, is available for the northern subspecies, despite its larger range, than for the southern subspecies. There are few accurate density figures for salt marsh harvest mice because: 1) their numbers are so low (hence errors of sampling are high), 2) most marshes are long, narrow fringing marshes that preclude the use of grid trapping (and hence make accurate density estimates difficult), and 3) accurate grid surveys require high levels of resources, in terms of time and cost, to conduct. However, in the face of severely reduced ecotonal habitat and continued predator pressure during high tide and flooding events, among other threats, we feel confident that salt marsh harvest mice suffer from small population levels throughout their range. Low population numbers are likely to fall even lower in the future, given sea level rise anticipated to accompany global climate change.





**Figure 1. Known distribution of salt marsh harvest mouse**

## Habitat/Ecosystem

The basic habitat of the salt marsh harvest mouse has been described as *Sarcocornia*-dominated vegetation (Dixon 1908; Fisler 1965). Other highly important habitat considerations include high tide/flood refugia of emergent *Grindelia* (gumplant; both at the upper edge of the marsh and within mature marshes, even at the highest high tides), seasonal use of terrestrial grassland, exploitation of suboptimal habitats, and habitat selection in brackish marsh vegetation where *Sarcocornia* is a relatively minor component, as often is the case in Suisun Bay marshes. Studies conducted jointly by CDFG and the DWR have shown that salt marsh harvest mouse populations are supported equally in mixed-halophyte and *Sarcocornia* microhabitats (Sustaita *et al.* 2005).

Salt marsh harvest mice are typically associated with tall, dense, continuous stands of *Sarcocornia pacifica* in saline soil. These stands remain mostly unsubmerged during periods of flooding, or are mixed with other unsubmerged sources of cover, such as taller vegetation (*Grindelia* or debris; Fisler 1965; Rice 1974; Johnson and Shellhammer 1988; Shellhammer *et al.* 1988; Bias and Morrison 1993; Hulst 2000). Within *Sarcocornia* marshes, the taller, denser stands tend to support the most salt marsh harvest mice, although they may also be abundant in tidal marshes with relatively short *Sarcocornia* canopies. A *Sarcocornia* canopy height of approximately 15 centimeters (6 inches) appears to be the lowest commonly used by salt marsh harvest mice (Fisler 1965; Shellhammer *et al.* 1982). The relationship between *Sarcocornia* height and salt marsh harvest mice abundance may depend on degree of canopy submergence rather than height alone. Stands of *Schoenoplectus americanus* (chairmaker's bulrush) may be important in providing unsubmerged habitat. Surveys in tidal and diked wetlands have confirmed that salt marsh harvest mice can be found using pure stands over 80 meters deep. Traps set at over one meter high have continuously captured salt marsh harvest mice at the same rate as mixed *Sarcocornia* wetland vegetation (Barthman-Thompson, *in litt.* 2009).

The ecological basis for the salt marsh harvest mouse affinity for *Sarcocornia* habitat is probably due to several factors, including year-round cover from predators, use of *Sarcocornia* as a food source, competition with other small mammals, and escape from flooding (Fisler 1965; Shellhammer *et al.* 1982, 1988; Geissel *et al.* 1988; Bias and Morrison 1993). These factors are not uniquely associated with *Sarcocornia*, however, and there is significant variation in vegetation types used by salt marsh harvest mice. Saline to subsaline marsh that lacks *Sarcocornia*, or supports it as a minor component, may be used as habitat by significant numbers of salt marsh harvest mice; this is especially the case in many parts of the Suisun Bay (Botti *et al.* 1986; Quickert, *in litt.* 2007). There is no trapping evidence to indicate that *Spartina foliosa* (Pacific cordgrass), some *Scirpus spp.* (bulrush, tule), and *Typha* (cattail) vegetation are more than marginal and incidental habitat for the salt marsh harvest mouse (Fisler 1965; Shellhammer *et al.* 1982), although recent studies (2000 through 2005) in the Grizzly Island and Hill Slough areas within the Suisun Marsh indicate a much greater use of *Schoenoplectus americanus* species than found in other portions of the range (Quickert, *in litt.* 2007).

Shellhammer *et al.* (1982) concluded that mixed stands of native salt marsh vegetation dominated by *Sarcocornia* may have higher habitat value than pure stands. Salt marsh plants suggested as beneficial in mixed stands include *Frankenia salina* (alkali-heath), *Atriplex*

*triangularis* (spearscale), and possibly small amounts of *Distichlis spicata* (saltgrass). The Mare Island *Sarcocornia* marshes are very low in vascular plant species diversity other than *Sarcocornia* and *Cuscuta salina* (parasitic dodder), but support exceptionally tall, dense *Sarcocornia* vegetation and an abundance of salt marsh harvest mice (Bias and Morrison 1993). Although salt marsh harvest mice have a high affinity for the annual salt marsh forb *Atriplex triangularis*, due to the inherent winter dieback of this species it has no significant winter habitat value (Rice 1974; Botti *et al.* 1986).

Salt marsh harvest mice commonly occur in the upper portions of salt marshes where terrestrial grasses are absent or remote, while western harvest mice tend to be dependent on proximity to terrestrial grass vegetation (Fisler 1965). However, salt marsh harvest mice frequently utilize terrestrial grassland habitats adjacent to salt marsh and grass-*Sarcocornia* ecotones (Zetterquist 1976; Shellhammer *et al.* 1982; Johnson and Shellhammer 1988; Shellhammer *et al.* 1988), and this use is highest in the late spring and early summer (Fisler 1965). Salt marsh harvest mice in eastern San Pablo Bay and Suisun Marsh (northern subspecies) appear to be more widespread in terrestrial grasslands and grassland-brackish marsh ecotones than those in the South San Francisco Bay (southern subspecies) because there is so little grassland edge there. Persistent low numbers of salt marsh harvest mice were found in predominantly grassland vegetation at Cullinan Ranch, which is adjacent to Mare Island Marsh, one of the most densely populated marshes for the species (Hulst 2000). There are few data available on the distance that salt marsh harvest mice are likely to travel from salt marsh into terrestrial grassland. Salt marsh harvest mice have been found seasonally using grasslands over 100 meters from any wetland edge in tidal marshes (Barthman-Thompson, *in litt.* 2009). Johnson and Shellhammer (1988) speculated that dispersal to grasslands may be driven by competition from California meadow voles, but this has not been consistently shown (Bias and Morrison 1993; Hulst 2000). The use of grasslands by salt marsh harvest mice in the spring has been interpreted as an opportunistic exploitation of a seasonally available resource, rather than use of an essential habitat (Fisler 1965; Johnson and Shellhammer 1988).

The extent to which salt marsh harvest mice used, or would use, native grasslands has not been investigated (Baye *et al.* 2000; Holstein 2000). Native grasses occur infrequently, but in local abundance, along the edges of tidal salt and brackish marshes in San Pablo Bay and the Suisun Marsh area. Cover is a limiting factor for both subspecies (Fisler 1965; Shellhammer, *in litt.* 2009), and native *Leymus triticoides* (wildrye) stands, which provide tall dense cover at all times of the year (Baye, pers. comm. 2004, 2007), may form a better marginal grassland habitat than annual European grasses.

*Lepidium latifolium* (perennial pepperweed) readily invades brackish middle marsh plains that support significant proportions of *Sarcocornia* vegetation and associated native salt marsh plants. It can overtop and shade a *Sarcocornia* understory, and displace all other tidal brackish marsh vegetation (Baye, pers. comm. 2004, 2007). *Lepidium latifolium* can form dense, often monotypic stands in high tidal marsh zones and terrestrial ecotones. Despite the great and increasing extent of *Lepidium latifolium* in brackish tidal marshes historically occupied by salt marsh harvest mice, there have been few quantitative investigations of this relationship. H.T. Harvey (2006) reported some mice in the South Bay in mixtures of alkali bulrush and

pepperweed and captured a few mice at pure pepperweed trapping locations, however, the extent to which mice use perennial *Lepidium latifolium* is not clear.

Studies have documented ecologically significant numbers of salt marsh harvest mice in what have been termed marginal, atypical, and suboptimal habitats (Botti *et al.* 1986; Geissel *et al.* 1988; Hulst 2000). For that reason, it is important to avoid sampling bias caused by locating survey lines only in stands of vegetation determined to be optimum habitat or those thought most likely to produce trap success. This practice ensures failure to identify atypical or suboptimal stands of vegetation that support ecologically significant populations of salt marsh harvest mice (Baye 2000; Baye *et al.* 2000). Very few studies have been conducted on the marsh plain in broad tidal salt marshes. This makes it difficult to comparatively assess population densities, and thereby the importance, of these tidal marshes. The few examples that exist (Calaveras Point, Highway 37 marshes) yield significantly high numbers of captures (Duke, pers. comm. 2005).

*Flood and tidal refugia.* Flooding as a factor in habitat quality for salt marsh harvest mice is closely related to vegetation and marsh structure. Flooding that submerges vegetation of the middle marsh plain may occur from very high tides near the summer and winter solstices, storm surges, and extreme river outflows into the estuary. Fisler (1965) concluded that the January and December tides were critical high tides that could endanger whole populations of salt marsh harvest mice. Prolonged flooding exposes salt marsh harvest mice to predators (discussed further under Factor C), and increases the risk of mortality due to exposure or drowning. Although salt marsh harvest mice float and swim well (Fisler 1965), and cross open water without being forced by flooding (Geissel *et al.* 1988; Bias and Morrison 1999), they do not swim as well as other small salt marsh mammals, nor do they dive (Johnston 1957). Mice move locally from flooded salt marsh to emergent high ground or vegetation. Salt marsh harvest mice likely remain in their home ranges during high tide immersion of marsh vegetation, and swim or cling to taller emergent portions of vegetation or floating debris (Johnston 1957; Hadaway and Newman 1971).

The relative importance of landward marsh edges as flood refugia for salt marsh harvest mice probably differs between narrow and deep tidal marshes. Flood refugia at landward marsh edges appear more important in narrow marshes where mice are concentrated during high tide and slightly less important in deeper marshes, given their intramarsh refugia. Shellhammer (Shellhammer, *in litt.* 2009) reports that this may be the case if the broad marsh is mature and has a complex channel system and hence berms on which *Grindelia* can grow, however, it may not be true for new broad marshes where the plain is not well dissected and hence does not vary in topography. Even in deep marsh plains, the available refugia may be limited to *Grindelia* vegetation, natural berms and levees, and trapped floating woody debris along marsh edges at creek banks (Johnston 1957; Hadaway and Newman 1971; Bias and Morrison 1993, 1999). *Schoenoplectus americanus* has also been shown to provide high tide refugia in Suisun (Barthman-Thompson, *in litt.* 2009).

*Salinity.* Salinity may influence salt marsh harvest mouse habitat independent of its correlation with *Sarcocornia*. Zetterquist (1978) found that salt marsh harvest mice were most abundant in portions of diked salt marshes where salinity was extremely high. A high physiological tolerance for salt in food and water (Fisler 1965; Coulombe 1970) may confer a competitive

advantage to salt marsh harvest mouse in harshly saline marsh habitats, particularly where competition with more aggressive, but less salt-tolerant, California voles occurs (Blaustein 1980, 1981; Geissel *et al.* 1988). This suggests that otherwise suboptimal hypersaline salt marsh vegetation and salt pans may provide important habitat exploited intermittently by salt marsh harvest mice to cope with interspecific competition. However, this conclusion is uncertain. The wide high tidal salt marsh plain at Mare Island Marsh consists of nearly pure stands of extremely tall, dense *Sarcocornia* with few local pans that are brackish for most of the year (Baye, pers. comm. 2007), yet this marsh supports consistently high populations of salt marsh harvest mice that coexist with California voles (Kovach and Pomeroy 1989; Bias and Morrison 1993, 1999). Similarly, many tall, dense stands of *Sarcocornia* non-tidal seasonal wetlands grow in non-saline to subsaline soils (Kovach and Pomeroy 1989; Baye, pers. comm. 2004, 2007).

#### Changes in Taxonomic Classification or Nomenclature

There have been no changes in taxonomic classification or nomenclature for the salt marsh harvest mouse since its listing in 1970.

#### Genetics

Two papers involving genetics work conducted in Suisun are currently in preparation : 1) Brown, S. and F. Villablanca. Genetic tests of hybridization between endangered *Reithrodontomys raviventris* and non endangered *Reithrodontomys megalotis* (Brown, S.K. 2003a); and 2) Brown, S and F. Villablanca. Genetic and morphological identification of an endangered species (*Reithrodontomys raviventris*) (Brown, S.K. 2003b).

#### Species-specific Research and/or Grant-supported Activities

The CDFG has one ongoing and one completed Endangered Species Act Section 6 grant. The objective of the first grant for “Salt-marsh harvest mouse radio- telemetry study in the Suisun Marsh” (Section 6 project EW03 XXIX-1) was to use movements of marked animals to determine habitat use, home range, and effects of seasonal flooding. This study is not yet complete, however, portions of this grant money was combined with work from another salt marsh harvest mouse study where preliminary results indicate that pickleweed (greater than 60 percent pickleweed) and mixed-wetland (greater than 60 percent various native and non-native wetland plant species, other than pickleweed and grasses) dominated microhabitats supported similar salt marsh harvest mouse densities, reproductive potential, and persistence throughout much of the year. Diked wetlands tended to contain higher densities, whereas tidal wetlands demonstrated greater long-term persistence. The relative cover of mixed-wetland vegetation with a high component of halophytes such as *Atriplex triangularis*, *Frankenia salina*, *Distichlis spicata*, *Juncus balticus*, and *Schoenoplectus* (formerly *Scirpus*) *americanus* was positively correlated with salt marsh harvest mouse abundance overall (Sustaita *et al.* 2005). Limited telemetry movement data was collected as transmitters did not remain attached for more than 2 days and movements were very erratic, possible due to transmitter placement. It is unlikely that telemetry will continue unless a better attachment system can be developed.

Home ranges and effects of seasonal flooding will be looked at with existing data from annual salt marsh harvest mouse surveys. Researchers have observed that habitat dominated by *Schoenoplectus americanus* with a thatch layer of 8 to 36 inches appears to provide salt marsh harvest mice with escape cover from flood events. Instead of moving into upland edges during high tides it appears that salt marsh harvest mice move upward in the vegetation and thus avoid inundation.

The objective of the second grant for "Control of perennial pepperweed in the Suisun Marsh to benefit the salt-marsh harvest mouse, California clapper rail, Suisun thistle, and soft bird's-beak" (Section 6 project EW04 XXIV-1) was to maximize acreage available to the salt marsh harvest mouse and three other species by reducing the amount of the invasive plant *Lepidium latifolium* (perennial pepperweed). This study suggests that an effective control method for perennial pepperweed in tidal wetlands in Suisun Marsh is a combination of Telar® XP (active ingredient Chlorsulfuron) applied above mean high tide on days without precipitation during periods of prolonged low tides at either the flowerbud stage (May) or fall (September/October), and Habitat® (Imazapyr) applied below mean high tide at the flowerbud stage or possibly fall. Care should be taken to avoid non-target vegetation when applying Habitat®.

### **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.

#### **Factor A: Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range**

The greatest historical and present threat to tidal marsh ecosystems and the salt marsh harvest mouse is the destruction and alteration of habitat. Habitat loss that threatens salt marsh harvest mice is due to filling, diking, subsidence, changes in water salinity, non-native species invasions, sea level rise associated with global climate change and pollution. In addition, habitat suitability of many marshes is further limited by small size, fragmentation, and lack of other vital features such as sufficient refugial habitat.

*Habitat loss.* Loss of tidal wetland habitat to urban and industrial development has been extensive in California. Only eight percent of the original pre-historical tidal marshes remain in the San Francisco Estuary (Goals Project 1999). As of 1999, only 40,000 acres of tidal marsh remained (Goals Project 1999). Specifically, the loss of tidal habitat has been through filling (*i.e.*, destruction), subsidence, and vegetation change (Service 1984; Bias and Morrison 1993; Shellhammer 2000). The high and middle, or *Sarcocornia* (pickleweed), zones, of tidal marshes have been the most affected. Shellhammer has found that the high marsh zone, once kilometers deep (from shore to bay) throughout the South San Francisco Bay, is now an interrupted band approximately 2 meters (6 feet) deep along 45 percent of the edge of that bay, a meter or less along 35 percent of the edge and 15 percent of edge had no high marsh at all (Shellhammer, *in litt.* 2009). The same study found that the adjacent upland edge (*i.e.*, the ecotone between marsh and upland) exists today in only 5 percent of the east side of the South Bay's edge (Shellhammer,



*in litt.* 2009). Habitat losses include areas associated primarily with historical diking and reclamation of tidal salt marshes, urban development of diked salt marshes, and adverse water management in diked brackish marshes of Suisun Marsh (Suisun Ecological Workgroup 2001).

Many hundreds of miles of dikes or levees dissect former tidal areas of the San Francisco Bay. Most were first constructed years ago to create salt ponds, allow agriculture, or for purposes related to flood control. Maintenance of dike systems continues to isolate marshes into areas too small to develop complex tidal drainage networks. Dikes ordinarily hinder normal circulation of tidal flows and drainage, with the result that diked areas have less tidal amplitude and flushing, and are either drier or wetter (or both, seasonally) than undisturbed marsh. Vegetation and soils are altered, for example, by persistent inundation or evaporative concentration of salts. Drying of marsh sediments has resulted in increased decomposition of organic matter in the soil or peat, causing subsidence of the ground surface. Groundwater pumping may also contribute to subsidence. Many diked areas are today substantially below sea level as a result, in some areas by more than six meters (20 feet).

Diking is often associated with artificial channelization, which, along with diking and marsh fragmentation, has led to a reduction in the amount and complexity of natural creek channels in remaining tidal marsh, which normally provides important habitat for many tidal marsh species. Also, dikes are now the only upland edges of many tidal marsh remnants. Dikes generally are too steep, narrow, and weedy to be high quality high-tidal refugia for tidal marsh animals. Dikes also greatly facilitate site access for both people and predators out into baylands that would otherwise be naturally isolated from frequent contact.

Other large net losses of nontidal occupied habitat have occurred since the publication of the first recovery plan including (1) grading and development of saline seasonal marsh adjacent to Mayhews Landing along old Jarvis Avenue in Newark; (2) re-emergent *Sarcocornia* in subsided, filled diked baylands at the residential Redwood Shores development; and (3) replacement of *Sarcocornia* with annual seasonal wetland forbs at the Gentry-Pierce site in Fairfield. The CDFG conducts a marsh-wide vegetation survey every three years which encompasses the entire Suisun Marsh. Analysis of the data from 1999 to 2003 showed there was an overall 682 acre (5.2 percent) decrease in all *Sarcocornia* types. However, the tidal wetlands within the study area exhibited a similar vegetation change percentage as the managed wetlands (CDFG 2004).

Habitat fragmentation occurs when tidal marsh habitat, once extensive and contiguous, is divided into relatively small discontinuous fragments. Fragmentation complicates the impact of habitat loss by reducing tidal marsh populations, not to one contiguous population a tenth of its former size, for example, but to many isolated tiny populations on habitat fragments of varying size, shape, and condition. In addition to the difficulty of supporting a viable population on a habitat fragment of limited area, marsh fragments may lack the full range of habitat features needed by a species throughout its life cycle. For example, a fragment might contain feeding and nesting habitat for the salt marsh harvest mouse, but completely lack refuge from high tides or storm surges.

As remaining marsh areas are reduced in size, edge effects become increasingly severe. Smaller populations and smaller (or narrower) habitats have less ability to absorb or buffer adverse impacts from outside influences, such as predation, human disturbance, or pollution.

*Habitat disturbance and degradation.* Significant habitat disturbance and degradation has continued in some portions of the salt marsh harvest mouse range. Numerous routine human activities can cause disturbance to salt marsh harvest mouse habitat, including maintenance activities for dikes, levees, flood control, vegetation control, recreational uses, human and domestic and feral animal incursion from adjoining developments (Goals Project 1999).

Ongoing high-magnitude wastewater discharges from sewage treatment operations and channelized urban runoff into tidal sloughs from San Jose to Milpitas (Guadalupe, Alviso, Artesian/Mallard Sloughs, Coyote Creek) have concentrated impacts on fringing tidal marshes. The perennial depression of channel water salinity during high freshwater flows has caused conversion of middle tidal marsh plains from salt marsh to brackish marsh dominated by species with very low or negative habitat value to the salt marsh harvest mouse (*Scirpus maritimus* [alkali bulrush], *Lepidium latifolium*), and reduced marsh salinity (H.T. Harvey and Associates 1997). During years of high rainfall, cumulative brackish marsh conversion problems are most severe, although high background freshwater outflows may mask the impact of wastewater discharges on brackish marsh conversion. As human population size and water use increases in the Santa Clara Valley, this problem may worsen.

Another form of salinity alteration is occurring in Suisun Marsh. Under normal conditions, Suisun Marsh salinity would be closely linked with Delta outflows and freshwater inflows from other creeks in the Suisun Marsh watershed, with considerable seasonal variation, from nearly fresh in spring, to brackish in the fall. During high rainfall years, lowered summer soil salinity would favor conversion of middle tidal marsh zones to *Scirpus*-dominated vegetation, causing decline of *Sarcocornia-Distichlis* (pickleweed-saltgrass) vegetation. During dry years, *Sarcocornia-Distichlis* vegetation would re-establish dominance and *Scirpus* vegetation would retreat (Suisun Ecological Workgroup 2001). Artificially stabilizing salinities at low levels during the summer and fall subdues the climate-driven pattern of vegetation fluctuations. These low salinity levels are harmful to species that favor plant communities of higher or more variable salinity, such as *Sarcocornia*. Water quality standards for salinity were modified in western Suisun Marsh by State Water Resources Control Board in 1999 (State Water Resources Control Board 1999) to allow greater climate-driven fluctuation. However, the artificially narrow low salinity range is still enforced in eastern Suisun Marsh.

Extirpated populations may fail to re-establish despite regeneration of suitable habitat conditions, possibly because of constraints on dispersal from source populations. Where few widely spaced source populations are separated by significant geographic or ecological barriers, there is little chance for recolonization by vagrant founders. Many narrow strip-like marshes are the only potential corridors between existing larger marshes. Narrow marshes (*i.e.*, those with shallow *Sarcocornia* marsh plains and very narrow high marsh zones) are highly unlikely to be functional corridors. Marshes of this type that are only 9 to 12 meters (30 to 40 feet) wide may be genetic and migration “filters”; and more narrow marshes, are likely to be complete barriers (Shellhammer, *in litt.* 2009).



Flooding of salt marsh harvest mouse habitat in diked baylands is influenced by (1) the degree of subsidence below sea level, (2) the efficiency of tide gate drains and drainage ditches operating at low tide, and (3) the magnitude and duration of flooding. Average rainfall seldom causes complete or widespread submergence of *Sarcocornia* canopies. Extremely high rainfall, managed intake of bay water, overtopping, and dike breaching all can completely submerge *Sarcocornia* canopies, and cause mass mortality and dispersal of salt marsh harvest mice (Fisler 1965). The greater the degree of subsidence, the greater the potential for catastrophic flooding of long duration. The 1983 flooding of the New Chicago Marsh in Alviso is an example of such potential flooding in a deeply subsided marsh. Coyote Creek overtopped, flooding all of Alviso, the New Chicago Marsh, and all the adjoining salt ponds. The marsh remained flooded for weeks, and levee tops surrounding the marsh (potential escape cover) were also underwater (Albertson, pers. comm. 2006). Routine flooding and draining associated with conventional methods of waterfowl marsh management in Suisun Marsh may cause prolonged submergence of salt marsh harvest mouse habitat. Overtopping of dikes by storm tides is a common phenomenon in San Francisco Bay during extreme high tides that will probably increase with rising sea level, and may be exacerbated by increased storm intensity predicted by global warming. Therefore, even diked salt marshes actively managed for long-term recovery of the salt marsh harvest mouse (Shellhammer 1989) may be at risk of catastrophic flooding.

*Invasive species.* One of the most pressing threats to the tidal marshes of California is invasion and modification of the ecosystem by non-native species—in the San Francisco Bay Estuary in particular, by *Spartina alterniflora* (eastern cordgrass). Non-native plant species capable of living in tidal marshes have invaded and profoundly altered vegetation, or threaten to do so, over extensive areas. Non-native plant species of greatest concern are those that (1) become so abundant that native plant species are diminished significantly in population size or displaced altogether, (2) become extensively dominant or develop nearly monotypic (single-species) stands, (3) colonize habitats naturally lacking in vascular plants, such as tidal flats, (4) alter natural sedimentation processes, or (5) are annuals that thereby provide no escape cover during winter high tides because they are simply a plant skeleton that predators can see through (Westbrooks 1998; Invasive *Spartina* Project 2008). Invasive species cause major impacts to the structure of vegetation, species competition, and composition within communities, and even to the soil-building properties of the tidal marsh ecosystem. Plant invasions harm tidal marsh animal populations by altering food availability or habitat structure (Nordby *et al.* 2004). The 2003 Suisun Marsh Vegetation Mapping Change Detection analysis determined that since 2000, *Lepidium latifolium* increased in tidal wetlands by 20 percent and 8 percent in diked wetlands (CDFG 2004). Invasions by non-native animals also affect tidal marsh species. To date, most animal impacts of concern have been those of non-native predators, such as red fox and Norway rats, on native prey species.

*Conservation.* Tidal marshes in California today are the focus of numerous diverse conservation efforts. Many significant preservation, restoration, management, education, monitoring, and research projects are being planned or are underway, and new initiatives are emerging continuously. Any attempt to catalog these efforts here is certain to be dated by the time of publication, and to neglect many important participants and projects. It must be noted, however, that the San Francisco Estuary Institute's Bay Area Wetland Project Tracker, San Francisco Bay

Joint Venture, Bay Conservation and Development Commission, San Francisco Bay Wetlands Restoration Program, Invasive Spartina Project, South Bay Salt Pond Restoration Project, and Suisun Marsh Program websites contain extensive information and maps about tidal marsh conservation and projects around the San Francisco Bay Estuary.

Following increased public awareness of tidal marsh destruction in the 1960s, public agencies (primarily the California Department of Fish and Game and the U.S. Fish and Wildlife Service, but including regional conservation districts, state and regional parks, and the State Lands Commission) acquired title to and protected many remaining tidal marshes throughout the San Francisco Bay Estuary. Tidal marshes in public ownership at Greco Island, Mowry and Dumbarton Marshes, Petaluma Marsh, Fagan Slough Marsh, Rush Ranch, China Camp, Point Pinole, Southampton Marsh, and Hill Slough contain irreplaceable pre-historical tidal marshes. These agencies also acquired many diked baylands under threat of development to reserve them for future restoration to tidal marsh (*e.g.*, Cullinan Ranch, Vallejo; Bair Island, Redwood City; Baumberg Tract, Hayward; Bel Marin Keys, Novato; Hamilton Field, Skaggs Island, etc.). Currently, restorations totaling more than 4,000 hectares (10,000 acres) have been completed and over 4,000 hectares (10,000 acres) more are in the planning phase ([www.wetlandtracker.org](http://www.wetlandtracker.org)). During the 1990s, the scale of proposed restoration projects generally increased from tens of acres typically in a mitigation context, to hundreds and thousands of acres in a restoration context. Current projects range from simple dike breaching to the use of dredge spoil to raise subsided historic baylands to elevations suitable for marsh establishment.

As of 2007, a total of 2,500 acres (1,012 hectares) made up of twelve individual parcels owned by the California Department of Fish and Game (10), the Suisun Resources Conservation District (1), and the Department of Water Resources (1) are managed as Mouse Conservation Areas. The establishment of these areas was a requirement of the U.S. Fish and Wildlife Service's 1981 biological opinion (U.S. Fish and Wildlife Service 1981) on the Suisun Marsh Management Plan, a plan developed by the U.S. Bureau of Reclamation and California Department of Water Resources to discuss development of a number of water conveyance facilities that would change the "major intake for *marsh* water supplies from Grizzly Bay to the Sacramento River near Collinsville, by introducing municipal waste water, and by redistributing water in major *marsh* channels".

The biological opinion specified via a conservation measure that the agencies set aside at least 2,500 acres of preferred salt *marsh* harvest mouse habitat to protect the species from the project impacts. These Mouse Conservation Areas are surveyed every three years to monitor salt *marsh* harvest mouse *populations*. In addition, aerial surveys are flown every three years to monitor preferred mouse habitat throughout the *marsh* and determine if pickleweed habitat is being lost. Other habitats used by salt marsh harvest mice in the Mouse Conservation Areas are not, to date, being assessed for vegetation change.

Many historically diked baylands have reverted to tidal mudflats and marsh following accidental or deliberate restoration of tidal flows. Many smaller tidal marsh restorations, mostly performed as mitigation for wetland destruction, have been conducted throughout the estuary. The habitat quality and success rates of restored tidal marshes have been variable due to many factors, including maturity of the restored site, design features, site selection and environmental setting,

invasion pressures by exotic species, tidal circulation and sediment supply, and initial site elevations and substrate conditions.

In summary, habitat loss accounts for the largest historical and present threat to the salt marsh harvest mouse. This loss had mainly been through filling, diking, subsidence, changes in water salinity, non-native species invasions, sea level rise associated with global climate change and pollution. Though restoration occurring now may eventually increase the total acreage of suitable habitat significantly, it is not likely to ever reach the level or quality present prior to listing. Additionally, though most habitat for salt marsh harvest mouse now occurs on protected public lands, the paucity of survey data makes difficult any assessment of distribution or increased abundance resulting from habitat restoration.

### **Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes**

Overutilization for commercial purposes was not known to be a factor in the 1970 final listing rule (Service 1970) for the salt marsh harvest mouse. Overutilization for any purpose does not appear to be a threat at this time.

### **Factor C: Disease or Predation**

Disease and predation were not known to be factors at the time of listing of the salt marsh harvest mouse. Disease is still not known to be a factor. However, elevated risks of flooding have resulted in salt marsh harvest mice moving to high ground, such as old dikes (Dixon 1908; Johnston 1957; Fisler 1965), resulting in significant predation risk.

*Predation.* Very little is known about predation impacts to the species. During high winter tides it is common to see great blue herons (*Ardea herodias*), great egrets (*Ardea alba*), snowy egrets (*Egretta thula*), ring-billed gulls (*Larus delawarensis*), California gulls (*Larus californicus*), and American kestrels (*Falco sparverius*) all taking small mammals from the upper edges and flooded areas of marshes. Protection from predators depends on the dense vegetation cover of typical salt marsh harvest mouse habitat. Salt marsh harvest mice that leave this cover, or those forced out by flooding, are exposed to predation by hawks and gulls by day, and short-eared owls (*Asio flammeus*) at night (Fisler 1965). Abundant white-tailed kites (*Elanus leucurus*) and northern harriers (*Circus cyaneus*) frequently forage over thickly vegetated diked and tidal *Sarcocornia* marshes in San Pablo Bay during all tidal stages, but their impact on salt marsh harvest mice is unknown. Clapper rails (*Rallus longirostris obsoletus*) and herons also occasionally take small mammals (Terres 1980; Josselyn 1983; Meanley 1985).

The impact of terrestrial predators on salt marsh harvest mice has not been studied. Potential terrestrial predators include red fox (*Vulpes vulpes*), gray fox (*Urocyon cinereoargenteus*), feral cats (*Felix domestica*), skunks (*Mephitis mephitis*), and raccoons (*Procyon lotor*). During extreme flooding of the marsh, there is increased dispersal of salt marsh harvest mice from Mare Island strip marshes across Highway 37, which can result in mortality from road kill. Less

extreme tides or floods that do not fully submerge marsh vegetation may not induce detectable dispersal (Hulst 2000). Movements across Hwy 37 are the exception. The more common threat to salt marsh harvest mice is that they are forced to the top of *Sarcocornia* as the highest high tides of the year rise and the animals are taken by predators. In marshes with a small total area of *Sarcocornia*, it is surmised (Shellhammer, pers. comm. 2005) that the death rate to predation and drowning exceeds the birth and immigration rate, and that these narrow marshes usually lose any salt marsh harvest mice.

Other than predation of exposed mice during marsh flooding events, predation is presumably greatest in habitats with incomplete or sparse cover, such as diked baylands with patchy vegetation and high proportions of annual grasses. These habitats also are usually closer to urban edges where terrestrial predators, such as feral cats, occur. The overall impact of non-flood predation on the recovery of salt marsh harvest mice is less significant than other factors such as habitat quality and size. Predation on tidal marshes is much more intense during the highest tides of the year; those at the two solstices when the marsh plains are almost totally submerged. Any tide that forces marsh plain-dwelling mice to swim exposes them to predation. Any narrow marsh with very little to no high marsh will either support no mice or lose mice to predation. Marsh plains with taller vegetation (*e.g.*, *Grindelia*) are likely to provide more protection to the mice (Shellhammer, *in litt.* 2009).

#### **Factor D: Inadequacy of Existing Regulatory Mechanisms**

There are several State and Federal laws and regulations that are pertinent to federally listed species, each of which may contribute in varying degrees to the conservation of federally listed and non-listed species. These laws, most of which have been enacted in the past 30 to 40 years, have greatly reduced or eliminated the threat of wholesale habitat destruction.

##### Federal Protections:

*Endangered Species Act of 1973, as amended:* The Endangered Species Act (Act) is the primary Federal law that provides protection for the salt marsh harvest mouse. The Service's responsibilities include administering the Act, including sections 7, 9, and 10 that address take. The Service has analyzed the potential effects of Federal projects under section 7(a)(2), which requires Federal agencies to consult with the Service prior to authorizing, funding, or carrying out activities that may affect listed species. 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 by reducing its reproduction, numbers, or distribution (50 CFR 402.02). A non-jeopardy opinion may include reasonable and prudent measures that minimize the amount or extent of incidental take of listed species associated with a project.

Section 9 prohibits the taking of any federally listed endangered or threatened species. Section 3(18) defines "take" to mean "to harass, harm, pursue, hunt, shoot, wound, kill,

trap, capture, or collect, or to attempt to engage in any such conduct.” Service regulations (50 CFR 17.3) define “harm” to include significant habitat modification or degradation which actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding or sheltering. Harassment is defined by the Service as an intentional or negligent action that creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering. The Act provides for civil and criminal penalties for the unlawful taking of listed species. Incidental take refers to taking of listed species that result from, but is not the purpose of, carrying out an otherwise lawful activity by a Federal agency or applicant (50 CFR 402.02). For projects without a Federal nexus that would likely result in incidental take of listed species, the Service may issue incidental take permits to non-Federal applicants pursuant to section 10(a)(1)(B). To qualify for an incidental take permit, applicants must develop, fund, and implement a Service-approved Habitat Conservation Plan (HCP) that details measures to minimize and mitigate the project’s adverse impacts to listed species. Regional HCPs in some areas now provide an additional layer of regulatory protection for covered species, and many of these HCPs are coordinated with California’s related Natural Community Conservation Planning program.

Salt marsh harvest mice occur with the geographic scope of two separate Habitat Conservation Plans (HCPs) currently in preparation: Pacific Gas and Electric’s Bay Area HCP and the Solano County HCP. Both of these planning efforts are in the early planning phase. Specific locations of potential salt marsh harvest mouse habitat disturbance or protection have not yet been identified.

*National Environmental Policy Act:* The National Environmental Policy Act (NEPA) [42 U.S.C. 4321 *et seq.*] was signed into law on January 1, 1970. The NEPA establishes national environmental policy and goals for the protection, maintenance, and enhancement of the environment and it provides a process for implementing these goals within the Federal agencies. The NEPA also establishes the Council on Environmental Quality (CEQ). Title I of NEPA contains a Declaration of National Environmental Policy which requires the Federal government to use all practicable means to create and maintain conditions under which man and nature can exist in productive harmony. Section 102 requires Federal agencies to incorporate environmental considerations in their planning and decision-making through a systematic interdisciplinary approach. Specifically, all Federal agencies are to prepare detailed statements assessing the environmental impact of and alternatives to major Federal actions significantly affecting the environment. These statements are commonly referred to as environmental impact statements (EIS). Section 102 also requires Federal agencies to lend appropriate support to initiatives and programs designed to anticipate and prevent a decline in the quality of mankind's world environment. All Federally-listed species that may be affected by a Federal project must be addressed by an environmental assessment (EA) and/or EIS. Prior to implementation of such projects with a Federal nexus, NEPA requires the agency to analyze the project for potential impacts to the human environment, including natural resources. In cases where that analysis reveals significant environmental effects, the Federal agency must propose mitigation alternatives that would offset those effects (40

CFR 1502.16). These mitigations usually provide some protection for listed species. However, NEPA does not require that adverse impacts be fully mitigated, only that impacts be assessed and the analysis disclosed to the public.

*The Lacey Act:* The salt marsh harvest mouse is protected by the Lacey Act (P.L. 97-79), as amended in 16 U.S.C. 3371. The Lacey Act makes unlawful the import, export, or transport of any wild animals whether alive or dead taken in violation of any U.S. or Indian tribal law, treaty, or regulation as well as the trade of any of these items acquired through violations of foreign law, and further makes unlawful the selling, receiving, acquisition or purchasing of any wild animal, alive or dead. The designation of wild animal includes parts, products, eggs, or offspring.

*Clean Water Act:* Under section 404, the U.S. Army Corps of Engineers (Corps) regulates the discharge of fill material into waters of the United States, which include navigable and isolated waters, headwaters, and adjacent wetlands (33 U.S.C. 1344). In general, the term “wetland” refers to areas meeting the Corps’s criteria of hydric soils, hydrology (either sufficient annual flooding or water on the soil surface), and hydrophytic vegetation (plants specifically adapted for growing in wetlands). Any action with the potential to impact Waters of the United States must be reviewed under the Clean Water Act, National Environmental Policy Act, and Endangered Species Act. These reviews require consideration of impacts to listed species and their habitats, and recommendations for mitigation of significant impacts.

The Corps interprets “the waters of the United States” expansively to include not only traditional navigable waters and wetlands, but also other defined waters that are adjacent or hydrologically connected to traditional navigable waters. However, recent Supreme Court rulings have called into question this definition. On June 19, 2006, the U.S. Supreme Court vacated two district court judgments that upheld this interpretation as it applied to two cases involving “isolated” wetlands. Currently, Corps regulatory oversight of such wetlands (*e.g.*, vernal pools) is in doubt because of their “isolated” nature. In response to the Supreme Court decision, the Corps and the Environmental Protection Agency (EPA) have recently released a memorandum providing guidelines for determining jurisdiction under the Clean Water Act. The guidelines provide for a case-by-case determination of a “significant nexus” standard that may protect some, but not all, isolated wetland habitat. The overall effect of the new permit guidelines on loss of isolated wetlands, such as tidal marsh habitat, is not known at this time.

#### State and Local Protections:

*California Endangered Species Act:* The California Endangered Species Act (CESA) (California Fish and Game Code, section 2080 *et seq.*), is a State law that provides protection for the salt marsh harvest mouse since the designation of this species as endangered on June 27, 1971. The CESA prohibits the unauthorized take of State-listed threatened or endangered species. The salt marsh harvest mouse was listed as endangered under CESA. The CESA requires State agencies to consult with the CDFG on activities that may affect a State-listed species and mitigate for any adverse impacts to

the species or its habitat. Pursuant to CESA, it is unlawful to import or export, take, possess, purchase, or sell any species or part or product of any species listed as endangered or threatened. The State may authorize permits for scientific, educational, or management purposes, and to allow take that is incidental to otherwise lawful activities. However, permits for take cannot be authorized due to the “Fully Protected” status of salt marsh harvest mice and CDFG cannot require mitigation because no take is allowed.

The salt marsh harvest mouse is a CDFG Fully Protected species. The classification of Fully Protected was the State's initial effort to identify and provide additional protection to those animals that were rare or faced possible extinction. Lists were created for fish, amphibians and reptiles, birds and mammals. Most of the species on these lists have subsequently been listed under the California and/or Federal Endangered Species Acts; white-tailed kite, golden eagle, trumpeter swan, northern elephant seal and ring-tailed cat are the exceptions. The white-tailed kite and the golden eagle are tracked in the California Natural Diversity Database (CNDDDB); the trumpeter swan, northern elephant seal and ring-tailed cat are not. The Fish and Game Code sections dealing with Fully Protected species state that these species "...may not be taken or possessed at any time and no provision of this code or any other law shall be construed to authorize the issuance of permits or licenses to take any fully protected" species, although take may be authorized for necessary scientific research. This language arguably makes the "Fully Protected" designation the strongest and most restrictive regarding the "take" of these species. In 2003 the code sections dealing with fully protected species were amended to allow CDFG to authorize take resulting from recovery activities for state-listed species. More information on Fully Protected species and the take provisions can be found in the Fish and Game Code, (birds at §3511, mammals at §4700, reptiles and amphibians at §5050, and fish at §5515). Additional information on Fully Protected fish can be found in the California Code of Regulations, Title 14, Division 1, Subdivision 1, Chapter 2, Article 4, §5.93.

*California Environmental Quality Act:* The California Environmental Quality Act (CEQA) requires full public disclosure of the potential environmental impact of proposed projects. The public agency with primary authority or jurisdiction over the project is designated as the lead agency and is responsible for conducting a review of the project and consulting with other agencies concerned with resources affected by the project. Section 15065 of CEQA guidelines requires a finding of significance if a project has the potential to “reduce the number or restrict the range of a rare or endangered plant or animal.” Species that are eligible for listing as rare, threatened or endangered but are not so listed are given the same protection as those species that are officially listed with the State. Once significant impacts are identified, the lead agency has the option to require mitigation for effects through changes in the project or to decide that overriding considerations make mitigation infeasible; however, this is not the case for salt marsh harvest mice due to its “Fully Protected” species status. In the later case, projects may be approved that cause significant environmental damage, such as destruction of endangered species. Protection of listed species through CEQA is, therefore, at the discretion of the lead agency. The CEQA provides that, when overriding social and economic considerations can be demonstrated, project proposals may go forward, even in cases

where the continued existence of the species may be jeopardized, or where adverse impacts are not mitigated to the point of insignificance.

*California Coastal Act:* The California Coastal Commission considers the presence of listed species in determining environmentally sensitive habitat lands subject to section 30240 of the California Coastal Act of 1976, which requires their protection. In particular the spirit of this act has two important precepts:

1. To promote the public safety, health, and welfare, and to protect public and private property, wildlife, marine fisheries, and other ocean resources, and the natural environment, it is necessary to protect the ecological balance of the coastal zone and prevent its deterioration and destruction.
2. That existing developed uses, and future developments that are carefully planned and developed consistent with the policies of this division, are essential to the economic and social well-being of the people of this state and especially to working persons employed within the coastal zone.

The California Coastal Act protects the habitat of the salt marsh harvest mouse because of two requirements presented in the legislation:

1. Environmentally sensitive habitat areas shall be protected against any significant disruption of habitat values, and only uses dependent on those resources shall be allowed within those areas.
2. Development in areas adjacent to environmentally sensitive habitat areas and parks and recreation areas shall be sited and designed to prevent impacts which would significantly degrade those areas, and shall be compatible with the continuance of those habitat and recreation areas.

Certain local jurisdictions have developed their own Local Coastal Programs or Land Use Plans that have been approved by the Coastal Commission. Some of the major accomplishments of this act include reduction in overall development, the acquisition of prime habitat along the coast, restoration of coastal streams and rivers, and a reduction in the rate of wetland loss.

### County and City

The San Francisco Bay Conservation and Development Commission (BCDC) have jurisdiction over the Suisun Marsh through the Suisun Marsh Protection Plan of 1976 (San Francisco Bay Conservation and Development Commission 2009).

### Summary of Regulatory Mechanisms

In summary, the Endangered Species Act is the primary Federal Law that provides protection for this species since its listing as endangered in 1970; and the Fully Protected



Status is the primary State Law that provides protection for this species since its listing as endangered in 1971.

Other Federal and State regulatory mechanisms provide discretionary protections for the species based on current management direction, but do not guarantee protection for the species absent its status under the Federal and State Acts. Therefore, we continue to believe other laws and regulations have limited ability to protect the species in absence of the Endangered Species Act and California Endangered Species Act. Various protections are afforded by these Acts including:

*Endangered Species Act:* Regulates activities that may result in take (hunt, harm, harass, capture, kill, shoot, trap, wound, or collect) of the salt marsh harvest mouse.

*California Endangered Species Act:* Pursuant to CESA, it is unlawful to import or export, take, possess, purchase, or sell any salt marsh harvest mouse or part or product of any species listed as endangered or threatened.

#### **Factor E: Other Natural or Manmade Factors Affecting Its Continued Existence**

Risk of small populations; contaminants; and global warming and climate change are currently identified as threats to the salt marsh harvest mouse.

*Risk of small populations:* There are few accurate density figures for salt marsh harvest mice because: 1) their numbers are so low (hence errors of sampling are high), 2) most marshes are long, narrow fringing marshes that preclude the use of grid trapping (and hence make accurate density estimates difficult), and 3) accurate grid surveys require high levels of resources, in terms of time and cost, to conduct. Salt marsh harvest mice depend on the ecotone between high marsh and uplands as escape refugia from predation during high tides and flooding events. Development has reduced this very habitat along the Bay to an average of six feet deep (Shellhammer pers. comm. 2005). Therefore, regardless of the paucity of survey data, in the face of severely reduced ecotonal habitat and continued predator pressure during high tide and flooding events, among other threats, we feel confident that salt marsh harvest mice suffer from small population levels throughout their range, with the possible exception of populations in Suisun marsh. Low population numbers are likely to fall even lower in the future, given sea level rise anticipated to accompany global climate change.

Several studies, in a wide range of habitats, have shown that *Reithrodontomys* populations are subject to periodic crashes and extinctions (M'Closkey 1972, O'Farrell 1973 and Whitford 1976). For long-term survival of *Reithrodontomys* in southern California marshes, Blaustein found immigration from adjacent populations was necessary (Blaustein 1981). Northern California *Reithrodontomys* suffering from small populations have limited opportunities for immigration in the face of existing fragmented habitat.

Small populations are typically at greater risk of extinction than larger ones (Terborgh and Winter 1980; Diamond 1984; Pimm *et al.* 1988; Morris and Doak 2003). Because salt marsh harvest mice have lost so much tidal marsh habitat, their populations are much

reduced in size. There are many causes of the increased risk of extinction characteristic of small populations. For example, small populations have increased vulnerability to extinction due to catastrophic events like severe droughts, storms, fires, pollution spills, non-native species invasion, or epidemics (Schonewald-Cox *et al.* 1983). Another factor is natural variability in birth and death rates: a chance cluster of years of high death rates or low birth rates is likely to result in the extirpation of small populations. At low population sizes, genetic and evolutionary effects become important, including loss of genetic diversity due to founder effects, genetic drift, inbreeding, and inbreeding depression.

*Contaminants:* Environmental contaminants may adversely affect the survival, growth, reproduction, health, or behavior of species. Some contaminants may affect a narrow range of organisms while others, like petroleum products, can impact a broader range of organisms. Known contaminants of concern in the San Francisco Bay Estuary include mercury, selenium, polychlorinated biphenyls (PCBs), organochlorine and organophosphate pesticides, dioxins/furans, polycyclic aromatic hydrocarbons (PAHs), and tributyltin from anti-fouling boat paints (State Water Resources Control Board 2006; Oros and Hunt 2005; Schwarzbach *et al.* 2006; Adelsbach and Maurer 2007). Ammonia and pyrethroid insecticides have become a recent concern. In addition, newly emerging contaminants which may act to disrupt endocrine systems, such as polybrominated diphenyl ethers (PBDEs) and phthalates, are being detected in the estuary's water, sediments, and biota (Oros *et al.* 2005; Oros and Hunt 2005) and are poorly understood. Unmonitored contaminants in San Francisco Bay include such chemicals as pharmaceuticals, plasticizers, flame retardants, and detergent additives (San Francisco Estuary Institute 2000). Toxic effects of many of these chemicals to harvest mice and other estuary biota are not known. In other species, some of these chemicals have caused endocrine disruption and altered gender development through in ovo exposures (Colburn and Clement 1992). While the full impact of these emerging contaminants on species in the estuary remains to be determined, the increasing frequency at which they are being detected is cause for concern. All of the contaminants mentioned above have the potential to adversely impact biota in the estuary, depending on the extent and degree of contamination (Phillips 1987).

The degree to which chemical contaminants, such as heavy metals, organochlorines, and PCBs affect the quality of salt marsh harvest mouse habitat is not known. Initial studies in San Francisco Bay and San Pablo Bay that analyzed small mammal tissue samples for selected contaminants were inconclusive for salt marsh harvest mice (Clark *et al.* 1992). The presence of relatively high concentrations of contaminants (*e.g.*, mercury, lead, cadmium, selenium) at salt marsh sites with some of the largest or most dense populations of salt marsh harvest mice such as Mare Island, Castro Creek Marsh, and Calaveras Point justifies additional investigation.

Salt marsh harvest mouse habitat is at risk of contamination due to oil spills, particularly along major gas and oil pipelines alongside Highway 680.

*Global warming and Climate Change:* The global average temperature has risen by approximately 0.6 degree Celsius during the 20th Century [International Panel on Climate Change (IPCC) 2001, 2007; Adger *et al.* 2007]. There is an international scientific consensus that most of the warming observed has been caused by human

activities (IPCC 2001, 2007; Adger *et al.* 2007), and that it is “very likely” that it is largely due to increasing concentrations of greenhouse gases (carbon dioxide, methane, nitrous oxide, and others) in the global atmosphere from burning fossil fuels and other human activities (IPCC 2007; Adger *et al.* 2007). Eleven of the twelve years between 1995 and 2006 rank among the twelve warmest years since global temperatures began in 1850 (Adger *et al.* 2007). The warming trend over the last fifty years is nearly twice that for the last 100 years (Adger *et al.* 2007). Looking forward, under a high emissions scenario, the IPCC estimates that global temperatures will rise another four degrees *Celsius* by the end of this Century; even under a low emissions growth scenario, the IPCC estimates that the global temperature will go up another 1.8 degrees *Celsius* (IPCC 2001). The increase in global average temperatures affects certain areas more than others. The western United States, in general, is experiencing more warming than the rest of the Nation, with the 11 western states averaging 1.7 degrees Fahrenheit warmer temperatures than this region’s average over the 20th Century. California, in particular, will suffer significant consequences as a result of global warming. In California, reduced snowpack will cause more winter flooding and summer drought, as well as higher temperatures in lakes and coastal areas. The incidence of wildfires in California also will increase and the amount of increase is highly dependent upon the extent of global warming. No less certain than the fact of global warming itself is the fact that global warming, unchecked, will harm biodiversity generally and cause the extinction of large numbers of species. If the global mean temperatures exceed a warming of two to three degrees *Celsius* above pre-industrial levels, 20 to 30 percent of plant and animal species will face an increasingly high risk of extinction (IPCC 2001, 2007). The mechanisms by which global warming may push already imperiled species closer or over the edge of extinction are multiple. Global warming increases the frequency of extreme weather events, such as heat waves, droughts, and storms (IPCC 2001, 2007). Extreme events, in turn may cause mass mortality of individuals and significantly contribute to determining which species will remain or occur in natural habitats. As the global climate warms, terrestrial habitats are moving northward and higher in elevation, but in the future, actual range contractions are more likely than northward or upslope shifts.

The maintenance of tidal marsh habitat area during sea level rise requires (1) space for tidal marshes to expand upward into adjacent habitats as sea and tide levels increase; (2) available sediment adequate to support marsh accretion rates equal to or greater than the rate of sea level rise; and (3) stable erosion rates, or at least rates that do not defeat marsh accretion. The first of these requirements—room for marshes to “move up” in elevation—is especially problematic in the many areas of the San Francisco Bay Estuary where tidal marsh abuts a dike, levee, seawall, or other human barrier at its landward edge. The requirement for moderate erosion rates is also of concern, given that climate change and sea level rise in California are expected to be accompanied by increased storm severity and maximum wave heights; trends that are already suggested by available data (Wilkinson 2002, Bromirski *et al.* 2004). Sediment supply for marsh accretion is not yet well understood.

Sea level rise will cause salinity levels to increase up the estuary as tides push higher up bays, rivers, and sloughs. For example, Suisun Bay and the Delta may become saltier. Species that prefer brackish conditions over salt marshes would presumably suffer reduction in habitat, while

salt marsh species might expand into Suisun Bay and even the Delta. It is not clear how changing salinity will affect salt marsh harvest mice since they exist in both brackish and saltier conditions. Closer study is needed of the potential amount and extent of salinity and habitat change, and the species-level effects of these changes.

Overall, threats from global climate change to salt marsh harvest mice include: (1) habitat loss where landward migration of tidal marsh habitat is prevented by artificial or geographic barriers, or where sea level rise or erosion exceeds sedimentation; (2) salinity gradients migrating up-estuary as tidal inundation increases; (3) greater extremes of heat and desiccation stress on habitat; (4) potential loss and/or decreased fecundity (Reid and Trexler 1991, Boorman 1992, Keldsen 1997); and (5) high mortality rates associated with extreme weather events (Downard in litt. 2009). The latter threat is likely to be the most devastating to salt marsh harvest mouse populations, which are known to fluctuate widely, even without significant storm events, and suffer from isolated populations with small numbers of individuals.

In summary, ongoing global climate change (Inkley *et al.* 2004; Anonymous 2007; Adger *et al.* 2007; Kanter 2007) likely imperils the salt marsh harvest mouse and the resources necessary for its survival. Since climate change threatens to disrupt annual weather patterns, it may result in a loss of its habitats and/or food, and/or increased numbers of their predators, parasites, and diseases. Where populations are isolated, a changing climate may result in local extinction, with range shifts precluded by lack of habitat.

### **III. RECOVERY CRITERIA**

The *Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California* was released for public comment in 2010 and includes the salt marsh harvest mouse. Recovery is the process by which the decline of an endangered or threatened species is arrested or reversed, and the threats to its survival are neutralized, so its long-term survival in nature can be ensured. The goal of this process is the maintenance of secure, self-sustaining wild populations of the species. Recovery plans 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. There are many paths to accomplishing the recovery of a species. Because we cannot envision the exact course that recovery may take and because our understanding of the vulnerability of a species to threats is very likely to change as more is learned about the species (*e.g.*, habitat, demography, genetics) and its threats, it is possible that a status review may indicate that downlisting or delisting is warranted although not all recovery criteria are met. Conversely, it is possible that the recovery criteria could be met and a status review may indicate that downlisting or delisting is not warranted (*e.g.*, a new threat may emerge that is not addressed by the recovery criteria below and that causes the species to remain threatened or endangered). 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. We focus our evaluation of species status in this 5-year review on progress that has been made toward recovery since the species was listed by eliminating

or reducing the threats discussed in the five-factor analysis. In that context, progress towards fulfilling recovery criteria serves to indicate the extent to which threat factors have been reduced or eliminated.

### **I. Downlisting criteria- Salt marsh harvest mouse**

**Factor A: The present destruction, modification or curtailment of its habitat or range.** To reclassify the salt marsh harvest mouse to threatened status, threats to the species habitat must be reduced. This will have been accomplished if the following have occurred:

**The protection, management and restoration of suitable tidal marsh habitat in each marsh complex is sufficient to support multiple viable habitat areas occupied by salt marsh harvest mice, that are distributed among recovery units as specified below in criteria A/1 through A/5.**

Each marsh complex must be as large and of as high a habitat quality as possible. These high quality marsh complexes will support larger populations of salt marsh harvest mice, and these complexes will likely persist, even in the face of such challenges as rising sea levels. Each marsh complex must meet a minimum acreage size, as specified below.

Marsh complexes will be comprised of one or more viable habitat areas (VHAs). Viable habitat areas for the salt marsh harvest mouse in the Central/Southern San Francisco Bay Recovery Unit, and San Pablo Bay Recovery Unit are defined as well-developed tidal marshes with the following specific features: 1) extensive *Sarcocornia* (pickleweed) on a mid to high marsh plain 200 meters or more deep (from shore to bay); 2) adjacent wide high marsh transition zone, wherever possible, that acts as refugia for the mice during the highest tides with sufficient area and cover to minimize predation risks and; 3) stands of *Grindelia* (and in San Pablo Bay area, *Scirpus* spp.) or tall forms of *Sarcocornia*, interspersed among shorter forms of *Sarcocornia* to provide additional high tide refugia within the marsh and away from the upland edge.

In addition, viable habitat areas for salt marsh harvest mice in the Suisun Bay Area Recovery Unit may be defined as muted, as well as fully tidal marsh. Viable habitat areas in the Suisun Bay Area Recovery Unit include the above important habitat features, but also include interspersed taller vegetation (*Schoenoplectus* (bulrush) and other species that are documented to be used by salt marsh harvest mice) (Quickert, *in litt.* 2007) as additional high tide refugia. Currently, a large proportion of salt marsh harvest mice in Suisun Marsh are supported by diked wetlands on Grizzly Island. Because of this and because lands here are subsided and would be nearly impossible to restore to tidal conditions, diked wetland acreage may be substituted for tidal marsh habitat when counting toward the viable habitat area acreage target within the Grizzly Island Marsh Complex only.

All VHAs within each marsh complex must be 150 acres or more, the minimum acreage thought to sustain a healthy mouse population (Shellhammer, pers. comm. 2005). The VHAs must be connected by corridors broad and complex enough to allow the interconnected VHAs to function

as one large population over time; however, these corridors will not be counted in the total marsh complex acreage, unless they are fringing marshes 500 feet deep (from shore to bay) or deeper and have excellent escape cover and some degree of high marsh transition zone.

Population criteria are based on capture efficiency data (*i.e.*, number of mice captured divided by effort in number of trap nights<sup>1</sup> expended times 100) because of high effort-low return on trapping and the great difficulty and great expense of obtaining dependable density estimates on a regular basis. Occupancy of multiple VHAs within a marsh complex at a capture efficiency level of 5.0 or better in some and 3.0 or better in most of the remaining VHAs is the primary indicator of a mouse population heading toward sustainability, while occupancy of multiple VHAs within a marsh complex at a capture efficiency level of 5.0 or better in most of the habitat areas is the primary indicator of a sustainable population (Shellhammer, pers. comm. 2005). The specific trap layout and spacing per site may differ.

### ***Recovery Units, Marsh Complexes, Viable Habitat Areas***

A/1. Central/Southern San Francisco Bay Recovery Unit: historic and restored marsh complexes at:

**Corte Madera Marsh**, 400 or more acres in size, with one VHA at:

- Corte Madera Marsh (State Ecological Area)

**Bair-Greco-Ravenswood**, 1,000 or more acres in size, with VHAs at:

- Foster City
- Bair Island
- Greco-Westpoint and Flood Sloughs
- Ravenswood Point and Slough

**East Palo Alto-Guadalupe Slough**, 1,000 or more acres in size, with VHAs at:

- East Palo Alto- Cooley Landing- Palo Alto Nature- Mountain View to Stevens Creek
- Stevens Creek to Guadalupe Slough

**Guadalupe Slough-Warm Springs**, 1,000 or more acres in size, with one VHA within the marsh complex

**Calaveras-Mowry-Dumbarton**, 1,000 or more acres in size, with one VHA within the marsh complex

**Hwys 84 to 92 (Coyote Hills-Baumberg)**, 1,000 or more acres in size, with VHAs at:

- Hwy 84 to Coyote Hills Slough
- Coyote Hills Slough to Hwy 92

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<sup>1</sup> A measure of trapping effort, *e.g.*, 400 trap nights represents 100 traps set for 4 nights.

**Cogswell-Hayward Shoreline, Oro Loma, Roberts Landing**, 1,000 or more acres in size, with VHAs at:

- Cogswell-Hayward Shoreline
- Oro Loma
- Roberts Landing

**Sub-criterion A: Protection of Documented Occurrences**

Habitat supporting all documented salt marsh harvest mouse occurrences must be protected via habitat management.

**Sub-criterion B: VHA Characteristics**

Each marsh complex must support VHAs, as described above, and these areas shall be connected by suitable habitat corridors with sufficiently deep (from shore to bay) pickleweed plains and/or sufficiently deep high marsh zones (and preferably both). This will allow movement of salt marsh harvest mice through these areas to occur unobstructed.

**Sub-criterion C: Marsh Connectivity**

Wherever possible, the marsh complexes themselves must be connected to one another by marsh or restored tidal marsh of sufficient depth and complexity to allow for dispersal and recolonization.

**Sub-criterion D: Marsh Complex Minimum Acreage**

Marsh complexes must be 1,000 acres or more in size, except in Corte Madera marsh where, due to constraints on restorable habitat, the marsh complex must be 400 acres or more in size. All VHAs within each marsh complex must be 150 acres or more in size.

The criteria for A/1 are still valid as described in the 2010 Draft Recovery Plan. To date, the target acreages for the Central/Southern San Francisco Bay Recovery Unit have not been met. Recovery actions in this unit are either underway or have not yet been planned or initiated. The Service is not aware of adequate surveys and monitoring of salt marsh harvest mouse populations in this recovery unit to make determinations regarding the amount of protected habitat, with salt marsh harvest mouse occurrences, connected by suitable habitat corridors to allow for successful reproduction, dispersal and recolonization.

A/2. San Pablo Bay Recovery Unit: historic and restored marsh complexes at:

**China Camp to the mouth of the Petaluma River**, 1,000 or more acres in size, with VHAs at:

- China Camp to Gallinas Creek and Gallinas Creek
- Hamilton Air Force Base marshes to Petaluma Point, including Novato Creek

**Petaluma River marshes**, 1,000 or more acres in size, with VHAs at:

- Bahia-Black John Slough-mouth of San Antonio Creek
- Petaluma Marsh and east of Petaluma River

- South-east of Petaluma Marsh

**Mouth of the Petaluma River to the mouth of Sonoma Creek**, 1,000 or more acres in size, with one VHA within the marsh complex

**Napa marshes from the mouth of Sonoma Creek to the southern tip of Mare Island**, 1,000 or more acres in size, with six VHAs within the marsh complex. These areas are dependent on the locations of the restored marshes.

**Point Pinole marsh**, 400 or more acres in size, with one VHA at:

- San Pablo Creek marshes and northeast from mouth of San Pablo Creek

**Sub- criterion A: Protection of Documented Occurrences**

Habitat supporting documented salt marsh harvest mouse occurrences must be protected via habitat management.

**Sub- criterion B: VHA Characteristics**

Each marsh complex must support VHAs, as described above, and these areas shall be connected by suitable habitat corridors with sufficiently deep (from shore to bay) pickleweed plains and/or sufficiently deep high marsh zones (and preferably both). This will allow movement of salt marsh harvest mice through these areas to occur unobstructed.

**Sub- criterion C: Marsh Connectivity**

Wherever possible, the marsh complexes themselves must be connected to one another by marsh or restored tidal marsh of sufficient depth and complexity to allow for dispersal and recolonization.

**Sub- criterion D: Marsh Complex Minimum Acreage**

Marsh complexes must be 1,000 acres or more in size, except in Point Pinole marsh where, due to constraints on restorable habitat, the marsh complex must be 400 acres or more in size. All VHAs within each marsh complex must be 150 acres or more in size.

The criteria for A/2 are still valid as described in the 2010 Draft Recovery Plan. To date, the target acreages for the San Pablo Bay Recovery Unit have not been met. Recovery actions in this unit are either underway or have not yet been planned or initiated. The Service is not aware of adequate surveys and monitoring of salt marsh harvest mouse populations in this recovery unit to make determinations regarding the amount of protected habitat, with salt marsh harvest mouse occurrences, connected by suitable habitat corridors to allow for successful reproduction, dispersal and recolonization.

A/3. Suisun Bay Area Recovery Unit: historic and restored marsh complexes at:

**Western Suisun/Hill Slough Marsh Complex**, 1,000 or more acres, with VHAs at:

- Morrow Island
- Cordelia Slough (west of railroad tracks)



- Chadbourne/Upper Wells Slough (west and east of railroad tracks)
- Peytonia
- Hill Slough complex

**Suisun Slough/Cutoff Slough Marsh Complex**, 1,000 or more acres, with VHAs at:

- Lower Joice Island
- Upper Joice Island
- Rush Landing to Beldon's Landing (east of Suisun and Cutoff Sloughs)
- Beldon's Landing to Nurse Slough

**Grizzly Island Marsh Complex**, 1,500 or more acres, with VHAs at:

- Grizzly Island West
- East border of Grizzly Bay, plus Crescent unit
- Grizzly Island East, including Ponds 1 and 15
- Simmons-Wheeler Islands
- Van Sickle Island/Chipps Island
- Ryer Island
- Montezuma area

**Nurse Slough/Denverton Slough Marsh Complex**, 1,000 or more acres, with VHAs at:

- Bradmoor Island- Little Honker Bay
- Blacklock
- Upper Nurse Slough

**Contra Costa County Shoreline Marsh Complex**, 500 or more acres, with VHAs at:

- Mallard Slough East
- Concord Naval Weapons Station marshes
- Hastings Slough to Carquinez Bridge

**Sub- criterion A: Protection of Documented Occurrences**

Habitat supporting documented salt marsh harvest mouse occurrences must be protected via habitat management.

**Sub- criterion B: VHA Characteristics**

Each marsh complex must support VHAs, as described above, and these areas shall be connected by suitable habitat corridors with sufficiently deep (from shore to bay) pickleweed plains and/or sufficiently deep high marsh zones (and preferably both). This will allow movement of salt marsh harvest mice through these areas to occur unobstructed. Isolated salt marsh harvest mouse preserves must be large enough to support mouse populations that will not lose genetic diversity due to random genetic drift over time.

**Sub- criterion C: Marsh Connectivity**

Wherever possible, the marsh complexes themselves must be connected to one another by suitable habitat of sufficient depth and complexity to allow for dispersal and recolonization.

**Sub- criterion D: Marsh Complex Minimum Acreage**

Most marsh complexes must be 1,000 or more acres in size. However, the Grizzly Island Marsh Complex must be 1,500 or more acres and the Contra Costa County Shoreline Marsh Complex must be 500 or more acres in size. All VHAs within each marsh complex must be 150 acres or more in size. Individual Mouse Conservation Areas, as defined in Chapter I of the 2010 Draft Recovery Plan under Tidal marsh conservation, restoration, and management, must be 150 or more acres in size and must have corridors to other preserves and/or to suitable habitat supporting salt marsh harvest mouse, wherever possible.

The criteria for A/3 are still valid as described in the 2010 Draft Recovery Plan. To date, the target acreages for the Suisun Bay Area Recovery Unit have not been met. Recovery actions in this unit are either underway or have not yet been planned or initiated. The Service is not aware of adequate surveys and monitoring of salt marsh harvest mouse populations in this recovery unit to make determinations regarding the amount of protected habitat, with salt marsh harvest mouse occurrences, connected by suitable habitat corridors to allow for successful reproduction, dispersal and recolonization.

- A/4. Treatment of extant invasive *Spartina alterniflora* and its hybrids and implementation of a system for its early detection. The definition of treatment success shall be equivalent to that developed by the California Coastal Conservancy's Invasive *Spartina* Project: that the system as a whole shall have no net increase in acres of invasive *Spartina* as measured against the 2001 baseline. Due to hybridization issues, monitoring will use indicators of progress and regress relative to evolving definitions of treatment success.

The criterion for A/4 is still valid according to the 2010 Draft Recovery Plan, however, it has not been met. Nevertheless, non-native *Spartina* control efforts in the San Francisco Bay have resulted in a more than 90 percent decrease in the overall population from the highest levels of 2004 (estimated at over 2,000 acres). Treatment efforts in 2010 are currently underway and will comprehensively address the remaining 10 percent (estimated to be less than 200 acres San Francisco Bay-wide). At the current rate of progress, the project will be approaching completion by 2012 (Grijalva, *in litt.* 2009).

- A/5. Reduction in extant *Lepidium latifolium* populations to less than 10 percent cover in each marsh complex described above.

The criterion for A/5 is still valid according to the 2010 Draft Recovery Plan, however, it has not been met. The Service is not aware of adequate surveys and monitoring of salt marsh harvest mouse populations in this recovery unit to make a determination that less than 10 percent cover remains in each marsh complex described above. This will be extremely difficult in the most brackish areas, such

as the southern end of the South San Francisco Bay. Research is needed to ascertain how to manage such areas to at least maintain a mixture of bulrush and other brackish species and pepperweed over time. Without such knowledge proper planning and success cannot happen (Shellhammer, *in litt.* 2009).

**Factor B: Overutilization for commercial, scientific or educational purposes.**

Overutilization currently is not known to be a factor for this species. Therefore, no recovery criteria are necessary for this factor.

**Factor C: Disease or predation.** Disease is not known to be a major threat to the salt marsh harvest mouse at this time. Unnatural predation is thought to exist in some marshes where salt marsh harvest mice are concentrated into narrow *Sarcocornia* zones due to surrounding habitat loss. Though little is known about death rates related to the resulting predation, it is presumed that restoration of deep marshes with ample high tide refugia, both high marsh and intermarsh, will result in a reduction of predation rates. Therefore, focus is given to restoration of high quality marshes and no recovery criteria related to predation are suggested.

**Factor D: Inadequacy of existing regulatory mechanisms.** We believe that if the threats under factors A, C and E are ameliorated, then additional regulatory mechanisms (beyond existing ones) are not necessary. Therefore, we are not proposing recovery criteria under this factor.

**Factor E: Other natural or manmade factors affecting its continued existence.** To reclassify the salt marsh harvest mouse to threatened status, the species must be protected from other natural or manmade factors known to affect its continued existence. This will have been accomplished if the following has occurred in the Central/Southern San Francisco Bay, San Pablo Bay, and Suisun Bay Area Recovery Units:

- E/1. Marsh Complex Population Occupancy Targets associated with A/1 through A/3
- 40 percent of the VHAs of each large marsh complex must have salt marsh harvest mice present at the capture efficiency level of 5.0 or better AND
  - 50 percent of the VHAs of each large marsh complex must have salt marsh harvest mice present at the capture efficiency level of 3.0 or better.
  - Each marsh complex must be monitored and found to meet the above criteria at least twice, with at least 5 years between surveys. Some marsh complexes may meet the target after only two surveys while it may take more than two surveys for other marsh complexes (restored marshes which eventually establish suitable habitat) to meet the target. After marsh complexes meet the criteria twice, there is no need to resurvey them, as long as no more than 20 years has passed and there has been no obvious negative change to habitat during that time (*i.e.*, substantial loss of upland transition or high marsh refugia due to sea level rise).

## **II. Delisting criteria- Salt marsh harvest mouse**

**Factor A: The present destruction, modification or curtailment of its habitat or range.** To delist the salt marsh harvest mouse, threats to the species habitat must be reduced. This will have been accomplished if the following have occurred:

A/1. All downlisting criteria under A/1 have been achieved.

These criteria are still valid. See downlisting criteria number A/1 above for status.

A/2. All downlisting criteria under A/2 have been achieved.

These criteria are still valid. See downlisting criteria number A/2 above for status.

A/3. All downlisting criteria under A/3 have been achieved.

These criteria are still valid. See downlisting criteria number A/3 above for status.

A/4. All downlisting criteria under A/4 have been achieved. In addition, a plan for eradication following any future detections of *Spartina alterniflora* or its hybrids must be in place. The definition of treatment success shall be equivalent to that developed by the Invasive *Spartina* Project: that the system as a whole shall have no net increase in acres of invasive *Spartina* as measured against the 2001 baseline. Due to hybridization issues, monitoring will use indicators of progress and regress relative to evolving definitions of treatment success.

This criterion is still valid. See downlisting criterion number A/4 above for status.

A/5. All downlisting criteria under A/5 have been achieved. In addition, a plan must be developed and implemented for early detection and control of *Lepidium latifolium* following any future increase beyond 10 percent cover. Also, a funding source must be secured to fund such actions in perpetuity.

This criterion is still valid. See downlisting criterion number A/5 above for status.

A/6. Implementation of the Habitat Management, Preservation, and Restoration Plan for Suisun Marsh, San Pablo Bay National Wildlife Refuge Comprehensive Conservation Plan, and the South Bay Salt Pond Restoration Plan.

This criterion is still valid.

The Habitat Management, Preservation, and Restoration Plan for Suisun Marsh is in preparation by the Suisun Marsh Charter Group<sup>2</sup> and the San Pablo Bay National Wildlife Refuge Comprehensive Conservation Plan is in preparation by San Pablo Bay National Wildlife Refuge. Therefore, no restoration activities have occurred to date.

The South Bay Salt Pond Restoration Project published the Draft Environmental Impact Statement/Environmental Impact Report (EIS/EIR) in March of 2007 and the Final EIS/EIR in December 2007. Habitat restoration and enhancement is or will be underway in 2010 in 11 South Bay ponds, comprising 3,081 acres (Island Ponds, SF2, A6, A5/7/8, E8A/9/8X) plus 1,400 acres in the North Bay at the Napa Plant site. The restoration design is near completion for the restoration and enhancement of another 3 ponds comprising 472 acres (E12/13, A16). Phase 1 construction is scheduled to be complete in 2012. In addition, a number of studies are underway that will help us understand how the Bay and its fish and wildlife resources are responding to the restoration, resulting in future restoration actions that are even more cost effective.

**Factor B: Overutilization for commercial, scientific or educational purposes.**

Overutilization currently is not known to be a factor for this species. Therefore, no recovery criteria are necessary for this factor.

**Factor C: Disease or predation.** Disease is not known to present a major threat to the salt marsh harvest mouse at this time. Unnatural predation is thought to exist in some marshes where salt marsh harvest mice are concentrated into narrow *Sarcocornia* zones due to surrounding habitat loss. Though little is known about death rates related to resulting predation, it is presumed that restoration of deep marshes with ample high tide refugia, both high marsh and intermarsh, will result in a reduction of predation rates. Therefore, focus is given to restoration of high quality marshes and no recovery criterion related to predation threat is provided. Therefore, no recovery criteria specific to this factor are necessary.

**Factor D: Inadequacy of existing regulatory mechanisms.** We believe that if the threats under factors A, C and E are ameliorated, then additional regulatory mechanisms (beyond existing ones) are not necessary. Therefore, we are not proposing recovery criteria under this factor.

**Factor E: Other natural or manmade factors affecting its continued existence.** To delist the salt marsh harvest mouse, the species must be protected from other natural or manmade factors known to affect its continued existence. This will have been accomplished if the following has occurred in the Central/Southern San Francisco Bay, San Pablo Bay, and Suisun Bay Area Recovery Units:

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<sup>2</sup> A multi-agency group with primary responsibility to protect and enhance the Pacific Flyway and existing wildlife values, endangered species, and water-project supply quality in Suisun Marsh. Members include U.S. Fish and Wildlife Service, National Marine Fisheries Service, U.S. Bureau of Reclamation (BOR), California Department of Fish and Game, California Department of Water Resources, California Bay-Delta Authority, and Suisun Resource Conservation District.

In addition to meeting all downlisting criteria above, to delist the salt marsh harvest mouse, a higher population occupancy target (Sub-criteria E) must be met, as follows:

- E/1. Marsh Complex Population Occupancy Targets associated with A/1 through A/3
- 75 percent of defined VHAs within each of the marsh complexes must have salt marsh harvest mice consistently present at the capture efficiency level of 5.0 or better.
  - As with the downlisting criteria, each marsh complex must be monitored and found to meet the above criteria at least twice, with at least 5 years between surveys. Some marsh complexes may meet the target after only two surveys while it may take more than two surveys for other marsh complexes (restored marshes which eventually establish suitable habitat) to meet the target. After marsh complexes meet the criteria twice, there is no need to resurvey them, as long as no more than 20 years has passed and there has been no obvious negative change to habitat during that time (*i.e.*, substantial loss of upland transition or high marsh refugia due to sea level rise).

These criteria for E/1 are still valid.

- E/2. To minimize impacts sustained after oil spills occurring at or near core populations, the San Francisco Bay and Delta Area section of the Sector San Francisco- Area Contingency Plan must be revised to place high priority on the emergency protection of salt marsh harvest mice.

This criterion for E/2 is still valid.

- E/3. High marsh/upland transition lands, when and wherever possible, must be preserved or created as part of new marsh restoration efforts and managed to provide opportunity for landward migration of species in response to sea level rise. In addition, there must be a partnership developed, involving resource agencies, public landowners/managers and private landowners, to implement Strategic Habitat Conservation, specifically to guide future habitat acquisition and management goals given the challenge of local sea level rise.

This criterion for E/3 is still valid.

#### **IV. SYNTHESIS**

Habitat loss due to human actions continues to be the greatest threat to the salt marsh harvest mouse. Habitat loss that threatens salt marsh harvest mouse is due to filling, diking, subsidence, changes in water salinity, non-native species invasions, sea level rise associated with global climate change and contamination. In addition, habitat suitability

of many marshes is further limited by small size, fragmentation, and lack of other vital features such as sufficient escape habitat. Larger tracts of high quality habitat are needed to maintain stable populations over time. Several projects such as the Habitat Management, Preservation, and Restoration Plan for Suisun Marsh, the San Pablo Bay National Wildlife Refuge Comprehensive Conservation Plan, and the South Bay Salt Pond Restoration Plan, which target restoration of salt marsh harvest mouse habitat, are either in preparation or in early implementation. The Service is not aware of any significant restoration of salt marsh harvest mouse habitat within this species' range that would meet the criteria identified in the Draft Recovery Plan and discussed in Section III of this review. Therefore, we believe the salt marsh harvest mouse (*Reithrodontomys raviventris*) still meets the definition of endangered, and recommend no status change at this time.

## 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 in recovery priority number.

## VI. RECOMMENDATIONS FOR ACTIONS OVER THE NEXT 5 YEARS

The basic strategy for recovery of the salt marsh harvest mouse is the protection, enhancement, and restoration of extensive, well-distributed habitat suitable for the species. The specifics must be modified for the similar, but distinct, recovery needs of the two subspecies. There are short- and long-term components of the general recovery strategy as well as specific geographic elements. Both interim and long-term components are necessary; neither alone is sufficient to recover the salt marsh harvest mouse. The 2010 Draft Recovery Plan identifies both long-term and short-term actions to recover salt marsh harvest mice populations. Below is a list of recommendations for actions over the next five years.

1. The most important data/research need at present is to fill in gaps in understanding of the current distribution, density, and demographics of the salt marsh harvest mouse. Most records are greater than ten years old and no systematic surveys have been carried out in key areas. Expectations of salt marsh harvest mouse population expansion into restored marshes are dependent on the presence of extant populations adjacent to restoration areas that can serve as source populations of the mouse. Resources for salt marsh harvest mouse surveys

- should be shifted from site-specific presence/absence surveys, to systematic regional surveys with replicated sampling over time. Surveys should give special emphasis to building upon information gained after the 2005 floods by tracking salt marsh harvest mouse (and other small salt marsh mammal) populations before and several years after major flood events, comparing population regeneration and extinction probabilities for a range of habitat types, sizes, and landscape positions (location along sloughs or bays, distances from nearest known populations or habitats). Regional survey programs for both subspecies should be established and funded for a minimum of 10 years or one flood/drought cycle.
2. High ground adjoining or near marshes should be acquired and protected. Existing steep-sided outboard dikes that back most of the marshes of the bay should be redesigned such that when they need to be replaced or heightened, in response to flooding threats from sea level rise, they have much more gradual slopes on their bay sides (*i.e.*, slopes of 10 to 1 or more rather than the 1 to 1 to 2 to 1 slopes that presently exist). High ground should be connected to marshes wherever possible. The hills to the west and northwest of Tolay Creek in the San Pablo Bay, for example, should be connected to the flood plain of that creek through acquisitions and easements such that there will be room for future high marsh growth in the future as the rising sea level swamps the creek. The same is true for the Potrero Hills in the Suisun Marsh area. More acquisitions and easements should be made around them so that the marshes surrounding them can migrate landward as sea levels rise. Such planning and acquisitions will help protect future marshes from losing their high marsh zones altogether.
  3. Further fill of low-lying wetlands, salt ponds or other presently nontidal areas adjacent to tidal salt marshes or narrow fringing marshes should be either prohibited or severely discouraged. Building on such areas will reduce the areas into which marshes can expand as sea level rises. Commercial or residential areas immediately adjacent to marshes, especially narrow fringing marshes, will take priority for protection to prevent the further fragmentation of already fragmented marshes of the bay.
  4. The relationship and potential use or avoidance of perennial *Lepidium latifolium* (pepperweed) by salt marsh harvest mice should be investigated. *Lepidium latifolium* is increasing in almost all of the more brackish parts of the San Francisco Bay and while we know that the mice will use mixtures of *Lepidium latifolium* and bulrush, we do not have information on how large monocultures of this species will effect salt marsh harvest mice. In addition, the use of bulrush and other brackish species in the South San Francisco Bay should be investigated. The H.T. Harvey 2006 study for the City of San Jose showed that the mice do use it but, "we do not know how the distribution, densities or the persistence of salt marsh harvest mice may change as the ratio of alkali bulrush to perennial peppergrass changes both seasonally and over longer periods of time. Neither do we know the size of a mouse's home range within stands of alkali bulrush, how far they move within it, or whether they live in it for prolonged periods of time."



5. Although the salt marsh harvest mouse is relatively well-known in the bay area, public understanding of its ecological needs should be improved. Age appropriate educational materials should be prepared collaboratively by species experts and public educators, and distributed to public schools, university programs and environmental journalists. Public outreach materials should focus on the principal threats to the species (with emphasis on local conservation issues), recovery strategies and actions, and the results or progress of local recovery actions.

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

**Salt marsh harvest mouse (*Reithrodontomys raviventris*)**

**Current Classification:** Endangered

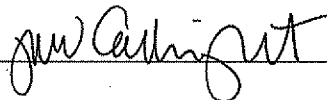
**Recommendation Resulting from the 5-Year Review:**

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

**Review Conducted By:** Sacramento Fish and Wildlife Office staff

**FIELD OFFICE APPROVAL:**

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

Approve  Date 2-16-10