# Science Foundation Chapter 5 Appendix 5.1 – Case Study Baylands Shrews

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## DESCRIPTION OF THE SPECIES

Three shrew species may occur in the marshes of the San Francisco Bay Estuary. None of the shrews of the Baylands are listed as threatened or endangered by either the state or the federal wildlife agencies but they are uncommon to rare and have disappeared from many known areas of potential habitat. The Draft Recovery Plan for Tidal Marsh Ecosystems of Northern and Central California (USFWS 2010) lists Suisun shrew (*Sorex ornatus sinuosus*) and salt marsh wandering shrew (*Sorex vagrans halicoetes*) as non-listed species covered by the recovery plan.

The Suisun shrew, one of nine subspecies of ornate shrew, may have originally had a range from Sonoma Creek in Sonoma County to Collinsville in Solano County (Rudd 1955, Brown and Rudd 1981). Other evidence points to Suisun shrews inhabiting only Grizzly Island until San Pablo Bay marshes were diked (Grinnell 1913; WESCO 1986). Today, Suisun shrews inhabit tidal and diked marshes of San Pablo Bay at recently-restored salt ponds near Napa and Devils Sloughs, Fagan Marsh, Tubbs Island and Tubbs Setback, Lower Tolay Creek, Mare Island Naval Shipyard, Sears Point, Sonoma Creek; and Suisun Bay at Rush Ranch (including Cutoff and Suisun Sloughs), Hill Slough, Meins Landing, Grizzly Island, and Cordelia Slough (WESCO 1986; CDFW, CDWR, USGS, USFWS unpublished trapping records; CNDDB). Hays and Lidicker (2000) noted that while the Suisun shrew was rare in many parts of its range, it may be locally common in locations such as their trapping area in Rush Ranch, where they captured 161 individuals in a 100m X 45m area across two seasons.

Northern ornate shrews (both *S. o. sinuosus* and *S. o. californicus*) are more similar, genetically, to neighboring populations of wandering shrews than they are to ornate shrew subspecies south of Solano County, California (Maldonado et al. 2004). Maldonado et al. (2004) suggests that wandering shrews may have been derived from ornate shrews. Salt marsh wandering shrews had a historic range from Contra Costa County down around the South San Francisco Bay and up to the southern portion of San Francisco County (WESCO 1985).

Today, salt marsh wandering shrew populations may be very low. One was captured at Don Edwards NWR in 2006 (USFWS unpublished trapping data), and in the 1980s at Newark Slough, Perry Gun Club, Sulfur Creek, Coyote Creek, and Coyote Hills Slough in Alameda County; and Triangle Marsh in Santa Clara County. Captures were in both tidal and diked marshes (USFWS unpublished trapping data). Shellhammer (unpublished trapping data) noted that after he captured 13 salt marsh wandering shrews in the Triangle Area north of Alviso in thousands of trap nights in the late 1970s, he failed to capture any more shrews in the South Bay marshes over the next 30 or more years. Most of the latter trapping efforts

occurred along the extremely narrow ecotone or juncture between marsh plains and the mixed halophytes along the base and lower portions of steep-sided dikes, the only upper edge available in most of the South Bay marshes. A third shrew, the little known "Fog" shrew (*Sorex vagrans sonomae*) may inhabit the marshes at China Camp State Park on the eastern side of the upper Marin Peninsula (Fisler 1965, Cummings 1975). No captures, however, were noted in 200 trap-night effort by Simons (Shellhammer and Simons 1980) in the most likely shrew habitat in that park. Two *Sorex* sp. were captured at the former Hamilton Air Force Base in Marin County in 1982, but not identified to species (USFWS unpublished trapping data).
A fourth shrew species, the California ornate shrew (*Sorex ornatus californicus*), occurs in the adjacent uplands and will not be described here. Assessing presence and numbers of shrews is very difficult. Capture rates are generally low and mortality rates are high when captured in metal box traps used to trap small rodents, even when insects are provided (CDFW, USGS, USFWS unpublished trapping data).

Several studies suggest that these Baylands shrew species occur most often at the marsh-upland ecotone, either between pickleweed (*Sarcocornia pacifica*) marshes and levees vegetated by coyote brush (*Baccharis pilularis*) and grasses (Hadaway and Newman 1971) or between undiked tidal marsh and ungrazed annual grassland (Hays and Lidicker 2000) vegetated by pickleweed, bulrush (*Schoenoplectus* spp.) and cattail (*Typha* spp.; Rudd 1955; CDFW, USGS, USFWS unpublished trapping data). Other vegetation types where captures occur include rush (*Juncus* spp.), gumplant (*Grindelia* sp.), alkali heath (*Frakenia salina*), marsh jaumea (*Jaumea carnosa*), saltgrass (*Distichlis spicata*), arrowgrass (*Triglochin maritima*), perennial pepperweed (*Lepidium latifolium*), and saltmarsh dodder (*Cuscuta salina*) (Hayes and Lidicker 2000; CDFW, USGS, USFWS unpublished trapping data). These shrew species may also be found in areas where the marsh edge is diked but the upland edge is undiked, such as the Hill Slough Wildlife Area in Suisun (CDFW unpublished trapping data).

Rudd suggested that habitat structure may be more important than species composition. These shrews require areas of fairly constant soil moisture with dense, low-lying plant cover in the 5-10 cm range, and abundant invertebrates (Johnston and Rudd 1957; USFWS 2010). They occupy the same middle and high marsh zone habitat as the salt marsh harvest mouse (Williams 1986). Driftwood and organic litter above the high tide inundation zone may be used for nesting and foraging, as well as refugia during warm dry periods (Johnston and Rudd 1957). Woody debris also provides habitat for insects on which they prey (Johnston and Rudd 1957). Nests are constructed above ground in dead vegetation lined with grasses or other soft materials or under woody debris or other cover (Gillihan and Foresman 2004). Suisun shrews excavate or may use existing subterranean burrows as movement corridors and for foraging (Bureau of Reclamation et al. 2011). Suisun shrews use the higher tidal wetland zones and upland transition zones as escape cover from high tides (Bureau of Reclamation et al. 2011). These shrews are constantly active and may consume well over their body weight in food every day (Gillihan and Foresman 2004). *S.v.halicoetes* consumes a variety of food: spiders, crickets, caterpillars, moths, slugs and slug eggs, beetles and beetle larvae, aphids, moth cocoons, maggots, carcasses of small rodents and birds, and fungi, flower parts, seeds, and other vegetation (Gillihan and Foresman 2004).

## REVIEW OF CLIMATE CHANGE EFFECTS ON THE SPECIES

In one study, Suisun shrews showed a pronounced loss of body weight in winter (30-40%), a condition more common in areas where food becomes scarce in winter (Hays and Lidicker 2000). Here, the author suggests habitat flooding may prevent shrews from foraging sufficiently. Hays and Lidicker (2000) also found evidence of a burrow system in the high tidal marsh, though shrews failed to move into the adjacent grassland. Shrews may also suffer from weather-induced stress in colder, wetter conditions due to their low heat content and high thermal conductivity (Hays 1990). Though salt marsh wandering shrews and Suisun shrews are capable of swimming (Johnston and Rudd 1957), they die quickly if their pelage becomes saturated in cold conditions (CDFW, USGS, USFWS unpublished trapping records).

One anticipated result of climate change is greater instances of peak flooding events by storms in combination with higher tides (Knowles 2009). Other small tidal marsh rodents (*i.e.*, salt marsh harvest mice [*Reithrodontomys raviventris*]) are known to move up in tall vegetation during high tides (Smith 2012) and also readily move into uplands (CDFW unpublished trapping records, Sustaita et al. 2011). If shrews lack these abilities, they are especially vulnerable to sea level rise, particularly extreme peak water events. According to the Recovery Plan, Suisun Bay, specifically the middle northern (Hill Slough) and northeastern (Nurse Slough) edges, offers more opportunities for restoration to tidal marsh-upland complexes with gentle gradients and room for sea level rise. However, much of this habitat is now grazed grassland. Salt marsh wandering shrews in the South Bay do not even have the option of moving into grasslands, as much of their habitat is bounded by urban development.

Suisun Shrew and particularly salt marsh wandering shrew are rare in San Francisco Bay marshes today because of the loss of their habitat, the ecotone between tidal marsh and adjacent upland vegetation. The survival of any or all of them depends on the protection and expansion of that ecotone. This is especially problematic in the South Bay, where little adjacent upland vegetation exists between Baylands and urban development, with little opportunity for marshes to move upward and landward as sea level rises. Throughout the Estuary, diked ponds restored to tidal marsh may not mature quickly enough to provide this high marsh/upland zone with limited sediment supply and rising sea levels (USFWS 2010). Ironically, even though all the parts of the Estuary have greatly lost sediment supply (Cloern and Jassby 2012), the marshes in the South Bay have the highest sedimentation rates in the Estuary and would more easily keep up with sea level rise than marshes to the north (Knowles 2009).

Even under high sedimentation rate and low sea-level rise rate scenarios, much of the high tidal marsh will be lost over the next 100 years in Suisun and San Pablo (including Marin County) Bay marshes (PRBO model). In the Central Bay, excluding Marin County, the band of high tidal marsh remains similar or may even increase under different sedimentation rate and sea-level rise scenarios. Under all scenarios, South Bay marshes also lose high tidal marsh, with the exception of a segment around Newark Slough and Mowry Slough which may only lose this band under high sea-level rise rate scenarios. However, not much high marsh exists in this area to begin with.

## OTHER STRESSORS

Mortality rates in *Sorex* species are high (Rose 1994). Fewer than half of all salt marsh wandering shrews live longer than 21 days (Johnston and Rudd 1957). Furthermore, though these shrews are just as vulnerable to extinction as salt marsh harvest mice, they are not protected under the Federal Endangered Species Act (USFWS 2010).

## INFLUENCES FROM OUTSIDE THE ESTUARY

The San Francisco Bay contains high levels of contaminants, such as petroleum-derived hydrocarbons, heavy metals, pesticides, and PCBs (Monroe and Kelly 1992, Luoma and Cloern 1982). Since shrews have very high metabolism rates and consume insects which may also concentrate contaminants, they may be especially vulnerable to both lethal and sublethal effects of these contaminants (Pankakoski et al. 1994).

## MANAGEMENT ACTIONS TO BE CONSIDERED

ecotone is important to prevent the invasion of the more upland form, *S. o. californicus*, and interbreeding between the two subspecies. They suggested that "it may be that provision of adequate upland and marsh habitats permits co-existence of both shrews with minimal contact between them."

The Draft Recovery Plan, which covers Suisun shrew and salt marsh wandering shrew, identifies general strategies to recover species, including, but not limited to, protecting remaining tidal marsh, restoring tidal marsh, controlling invasive plants, and controlling non-native or artificially abundant predators. Specifically, the Plan calls for directing restoration to benefit species population nuclei, while minimizing impacts. High marsh halophyte zones, marsh-to-terrestrial ecotones, and broad connections to adjacent uplands are specifically outlined. Specific predator control includes removing dike access, and providing high tide refugial habitat isolated from dikes within large marshes. The Plan also suggests creating "long, gentle gradients" to accommodate sea level rise. This can be accomplished at Rush Ranch, where Solano Land Trust owns both tidal marsh and the adjacent grasslands. Elsewhere, this is not easily accomplished. Where tidal marsh is unable to expand with sea level rise, and levees must be maintained, "habitat" (levees with wide bases and gentle slopes) or "horizontal" (levees with an upland ecotone slope of moist grasslands and brackish marshes landward of the existing tidal marsh; ESA/PWA 2013) levees may mimic high marsh bands.

WESCO (1986) estimated that 92% of the wetlands in historic range of the salt marsh wandering shrew have been lost and identified 15 locations throughout its former range that might potentially support populations. These areas should be evaluated for potential reintroduction of this species.

Recommendations from highest to lowest priority are listed here:

• For tidal restoration designs, incorporate wide and gently sloping high marsh and upland bands. Ideally, these areas should include upland edges with sufficient space to accommodate sea level rise.

• For managed marsh enhancement designs, incorporate wide "habitat" or "horizontal" levees, or, where possible, eliminate levees altogether at the upland edge.

• Protect high marsh and upland habitats in existing tidal and managed marshes.

• Reduce or prevent terrestrial predators from gaining access to the marshes in which shrews are found or might be introduced.

• Identify areas around the Bay where shrews can potentially be introduced or reintroduced. These areas should include upland edges with sufficient space to accommodate sea level rise.

• If safe and effective trapping methods can be employed, conduct live-capture surveys throughout the range of Bayland shrews to determine current population centers in order to prioritize restoration projects.

• Control invasive plants, and non-native or artificially abundant predators.

## UNCERTAINTY AND KNOWLEDGE GAPS

We do not know the potential for interbreeding between the Suisun shrew and the California subspecies of *Sorex ornatus*. This potential is described by Hays and Lidicker (2000). They are the only investigators who have trapped a sizeable population of these shrews over a long period of time and they failed to detect any movements of shrews into or out of adjacent grasslands. According to Hays and Lidicker (2000), "this emphasizes what appear to be the unique behavior and physiology of the Suisun shrew, and suggests that interbreeding with the subspecies *S. o. californicus* may be caused by invasion of the marsh by this upland form, and not the reverse. It may be that provision of adequate upland and marsh habitats permits the co-existence of both shrews with little contact between them."

To add to our lack of understanding of these shrew species, survey methods which may tell us more are particularly problematic. Hays (1998) created custom traps to capture these shrew species with minimal mortality. However, most researchers use metal traps or pitfall traps which are set before nightfall and checked the next morning. Even with the addition of bedding and insects, about half of all shrews captured by these methods die (CDFW, USGS, USFWS unpublished trapping records). Added to problematic capture methods is the limitation of unreliable species identification (Harding 2000).

Research needs to be conducted on bioaccumulation and effects of toxic estuarine contaminants on fecundity and viability of shrews. The results of the research should be applied to water quality standards for the San Francisco Bay Estuary (USFWS 2010).

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