Salt Marsh Harvest Mice, Urban Development, and Rising Sea Levels
Author(s): Howard S. Shellhammer
Source: *Conservation Biology*, Vol. 3, No. 1 (Mar., 1989), pp. 59-65
Published by: Wiley for Society for Conservation Biology
Stable URL: https://www.jstor.org/stable/2385990

Salt Marsh Harvest Mice, Urban Development, and Rising Sea Levels

HOWARD S. SHELLHAMMER

Department of Biological Sciences
San Jose State University
1 Washington Square
San Jose, California 95192-0100, U.S.A.

Abstract: *The salt marsh harvest mouse,* Reithrodontomys raviventris, *is endemic to the marshes of San Francisco Bay. Ultimate factors such as rising sea level and tectonic changes will play important roles in the future management of the mouse, causing a shift from tidal marshes threatened by submergence to diked marshes threatened by development. Land values and government regulations force the United States Fish and Wildlife Service and other agencies into proximate management strategies to recover the species. Whether large enough areas of diked marsh can be acquired in the near future to adequately protect the mouse in perpetuity is questioned.*

Resumen: *El roedor recolector de sal* Reithrodontomys raviventris *es endémico a las marismas de la Bahía de San Francisco. Factores determinantes tales como el incremento del nivel del mar y cambios tectónicos jugaran un papel muy importante en el futuro manejo de esta especie debido a que se verifica un cambio en su habitat de marismas regulados por la marea y amenazadas por la inundación, a marismas con represas amenazados por el desarrollo. El costo de los bienes raíces y las regulaciones gubernamentales están presionando a la Agencia de Pesca y Vida Silvestre de los Estados Unidos y a otras similares, al desarrolo de estrategias de manejo con el propósito de recuperar esta especie. El asunto en cuestión es si, áreas suficientemente extensas de marismas con represas pueden ser adequiridas en el futuro cercano a fin de proteger a este roeder a perpetuidad.*

Introduction

E. O. Wilson (1975) applied the terms "ultimate causation" and "proximate causation" to the study of sociobiology. He suggested that weather, predators, new habitats, new food sources, and other pressures are the ultimate causative mechanisms; the anatomical, physiological, and behavioral machinery of life are the proximate mechanisms.

The same dualism of ultimate versus proximate is applicable to conservation strategies. Often the biopolitical battles involved in preserving a species or habitat focus on proximate strategies. The lack of long-term planning often greatly diminishes the value of such short-term actions. This is especially the case when major climatic changes are involved. Peters & Darling (1985) stated that "conservation plans should reflect knowledge of climatic effects as soon as it becomes available" (p. 707). Such knowledge is just beginning to develop in the case of the greenhouse effect, the carbon dioxide buildup in our atmosphere. While controversy continues about its magnitude and timing, scientists generally accept that CO_2 levels and world temperature are increasing and that there are associated changes in sea level. Some suggest that such changes might be as sudden in the future as they appear to have been in the

Paper submitted June 20, 1988; revised manuscript accepted September 13, 1988.

past when major shifts in temperature took place in several centuries or less (Broecker 1987).

Peters & Darling (1985) discussed the potential impact of global warming on biological reserves worldwide. A regional example of this problem and of conflicting strategies is that of the salt marsh harvest mouse, *Reithrodontomys raviventris,* a species endemic to the San Francisco Bay region of California. The mouse was declared an endangered species by the United States Department of the Interior in 1970 and by the California Department of Fish and Game in 1971 (Shellhammer 1982). A recovery plan for it and the California clapper rail, *Rallus longirostris obsoletus,* was published by the U.S. Fish and Wildlife Service in 1984.

The Salt Marsh Harvest Mouse

This species is divided into two subspecies. *Reithrodontomys raviventris halicoetes* is found in the marshes of San Pablo and Suisun bays and along the northern Contra Costa County coast (Fig. 1). A few populations of the southern subspecies, *R. r. raviventris,* still exist on the Marin Peninsula and near Point Richmond. Most of the populations of this subspecies are found along the southern half of the South San Francisco Bay, the portion of the San Francisco Bay that is experiencing the most urban development. The reader should note (Fig. 1) that, for purposes of this paper, the San Francisco Bay Estuary is divided into the San Pablo, Central San Francisco, South San Francisco, and Suisun Bays.

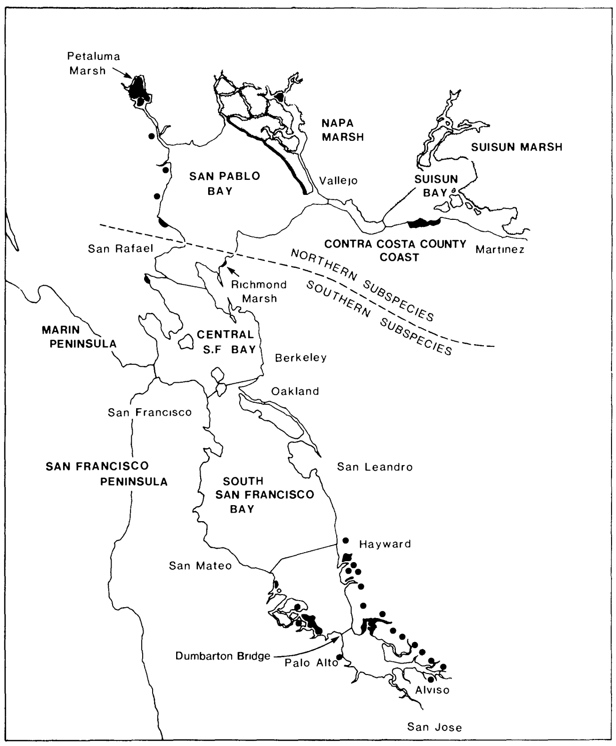

Figure 1. Geographic distribution of the Salt marsh harvest mouse. Major tidal and diked populations are shown in black; stipled areas indicate areas of numerous smaller marshes.

The salt marsh harvest mouse is dependent on dense cover and is restricted to salt and diked marshes around the estuary, where it utilizes common pickleweed, *Salicornia virginica,* as its preferred habitat. The mouse can swim well and tolerate high salinities in its food and drink (Fisler 1963, 1965); the subspecies *raviventris* can undergo daily torpor (Fisler 1965). Both subspecies typically inhabit the uppermost zone of tidal marshes and seldom-flooded transitional zones, which I term the zone of "peripheral halophytes" (Fig. 2). Given the proper moisture regime, the mouse is preadapted to live in a variety of diked salt marsh habitats dominated by pickleweed and associated wetland and transitional plants. There it appears to act as a refugial species as it utilizes poorer microhabitats (saltier and shorter pickleweed and associated halophytes) when the numbers of California meadow mice, *Microtus californicus,* are high (Geissel et al. 1988).

This species has become endangered primarily due to the destruction and modification of its habitat. Approximately 80 percent of the historical tidal marshes of the estuary have been filled or otherwise highly modified (Jones and Stokes et al. 1979). Most of the tidal marshes that remain support few or no mice because of backfilling, subsidence, or vegetation changes (Shellhammer 1982). Thirty-two percent of the original 473.5 km^2 of historical tidal marshes have been converted into diked marshes, 19 percent into diked salt ponds, 19 percent

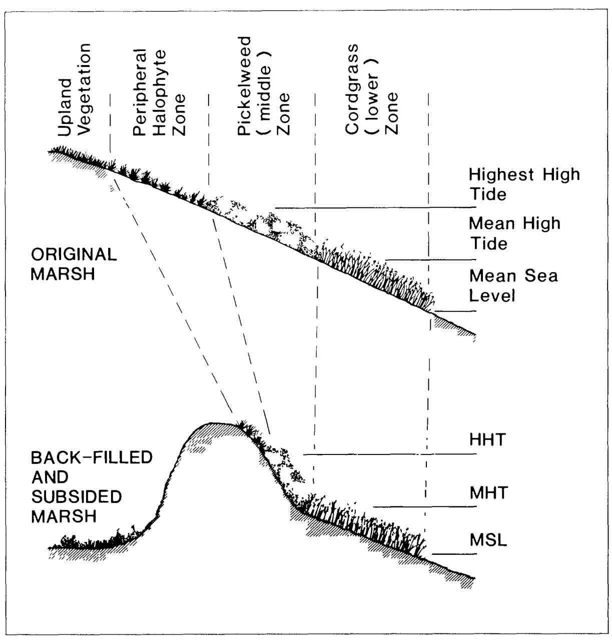

Figure 2. Vegetation profiles of tidal and diked marshes.

into agricultural land, and the rest into barren or ruderal areas and various types of ponds (Jones and Stokes et al. 1979). Eighty percent of the diked marshes exist in the Suisun Bay marshes where managing waterfowl habitat is the primary goal, but where a number of small, disjunct populations of the northern subspecies still exist (Harvey and Stanley Associates 1980). Many of the diked marshes along the southeastern side of South San Francisco Bay support small to moderate populations of the southern subspecies (Shellhammer et al. 1989). Many populations of the southern subspecies are now disjunct and isolated and have been for a period of unknown length—perhaps 15 to 40 years.

Relatively little is known of the genetics of the mouse or its demographic stochasticity over time. Nelson et al. (1984) reported that both subspecies demonstrated 10 percent heterozygosity in 30 allozymes tested, with some differences between subspecies. The sample size ($N = 4$), however, is too small to make valid assumptions about species-wide heterozygosity or accurately estimate genetically effective population size. Consultant trapping studies carried out by the author (for Harvey and Stanley Associates of Alviso, Calif.) and by other consulting firms (for the U.S. Fish and Wildlife Service and the California Department of Fish and Game) have been brief — from several days to a few months. Their location and season have also varied, and they were seldom repeated in the same locality in succeeding years. The longest continuous, intensive study in a tidal marsh (Rice 1974) lasted four months; the longest in a diked marsh (Geissel et al. 1988) lasted four and a half months. Hence, little is known of demographic stochasticity over a period of years. Only qualitative observations can be made about environmental stochasticity. Most tidal marshes have been highly modified and continue to change in elevation, type of vegetative cover, salinity of water, or amount and abundance of escape cover. Most diked marshes are either unmanaged, farmed for hay, diked for mosquito control, or used as flood control basins, and historically they may have been put to several of these uses. Flood basins are especially variable as they may be alternately flooded and very dry in the course of one year.

The Recovery Plan

The Recovery Plan for the mouse and rail (USFWS 1984) seeks to secure and manage a series of complete, productive marshes throughout their respective ranges. To do this, marshes within existing federal, state, and local jurisdictions must be identified; private lands must be acquired; and other tidal marshes and diked, historic bay lands, both public and private, must be restored or enhanced. The plan stipulates that "Individual marshes must be of sufficient size and habitat quality to support populations of one or both species [i.e., the mouse or rail] in perpetuity. In the case of the mouse, sufficiently large areas of marsh should be established to provide a 'Level 9' protection (Schonewald-Cox 1983)" (p. 46). Level 9 protection requires that some preserves be large enough to contain several populations of minimum viable size.

The plan also has a loftier purpose, one that is much more difficult to accomplish.

> In that the primary purpose of the Endangered Species Act is to conserve the ecosystems upon which endangered and threatened species depend, the underlying goal of this recovery plan is to conserve the ecosystem supporting the salt marsh harvest mouse and California clapper rail. The primary emphasis of this plan, the restoration and protection of mouse and rail habitat, is viewed as a small, but significant, part of the effort needed to conserve the entire Bay/Delta marsh ecosystem. Only through a broad-based program of ecosystem management can these species be recovered and the diversity of habitats maintained that were once part of the system (USFWS 1984, p. 12).

The role of diked marshes as mouse habitat is recognized in the plan, but not emphasized. Most of the strategies of the plan are proximate ones. Like most recovery plans, they include proximate objectives directed toward securing and managing marshes in various portions of the Bay, developing management plans for various areas, and identifying various subjects of future study. The plan notes that increasing development, pollution, and other human impacts play major roles within the Bay ecosystem, but it does not address such ultimate objectives as how to plan for rapid ecosystem changes such as the rapid increase in sea level. However, management plans are updated periodically, and I expect the impacts of the rapid rise in sea level to be incorporated in the first revision of the plan.

Consequences of a Rise in Sea Level Within the Bay

The potential impact of an accelerated rise in sea level in the San Francisco Bay was first described by Williams (1985) in a report to the San Francisco Bay Conservation and Development Commission (BCDC). The increase is attributed to thermal expansion, partial melting of glacial and polar ice, and tectonic sinking. Williams assumed a rise of 1.2 m in the sea level of the Bay during the next 100 years using the middle range of best- and worst-case scenario estimates of the U.S. Environmental Protection Agency (EPA) (1983) and the National Research Council (1987). This figure represents an eightfold acceleration of the historic rate of rise of sea level. Fort Point (San Francisco), the location of one of the longest continuously recording tide gauges in the world, has recorded a 0.2 m rise in the last century.

If Williams's projection is correct, the sea level of the Bay will rise that much in the next 17 years.

A more extensive investigation commissioned by BCDC assumed a lower average figure of sea level rise but noted that tectonic sinking varies throughout the estuary, causing some areas to be influenced more strongly than others (Moffatt and Nichol et al. 1987). Using the Fort Point tidal gauge 100-year average rate of increase (0.0012 m/yr), historic changes in sea level were estimated for locations around San Francisco Bay. Predictions for changes in sea level in 20 and 50 years were based on a 0.0022 m/yr increase characteristic of the rate of change at Fort Point during the last 19 years. The latter estimates project a relatively small rate of increase in relative mean sea level (RMSL, the difference between changes in sea level and either tectonic rising or sinking) (Moffatt and Nichol et al. 1987), in the San Pablo Bay and northern part of the South Bay (0.06 to 0.14 m) in the next 50 years, and a somewhat larger rise in the Suisun Bay (0.20 to 0.25 m). However, the middle and southern portions of the South San Francisco Bay are expected to experience more significant RMSL increases of 0.34–0.43 m and 1.51 m respectively. Hence, the greatest impact of the rise in RMSL is predicted to be in the most important part of the range of the *R. r. raviventris* subspecies. The study of Moffatt and Nichol et al., however, has some problems. Some evidence suggests that subsidence has apparently ceased or slowed greatly in the South San Francisco Bay (Poland & Ireland 1985). Controversy continues about the amount of present and future subsidence there, but it appears that the projected RMSL changes will be less than originally predicted by Moffatt and Nichol et al. (1987). It is the author's position, however, that managers of Bay wetlands should assume that the predictions in the EPA and NRC reports are closer to the truth, for without cautious long-term planning it is possible that the mouse may become extinct in many parts of the Bay.

The rise in RMSL is only part of the story, at least with respect to tidal salt marshes; sedimentation rates constitute most of the rest. The major sources of sediment for the wetlands of the estuary are the Sacramento and San Joaquin Rivers, in amounts directly related to total river discharge (Krone 1979). Dams and water use upstream will cut sediment supply by 45 percent by 1990 (Moffatt and Nichol et al. 1987). As a result, Krone (1979) determined that the South San Francisco Bay in general was losing sediment although some of the most southerly South Bay marshes seem to have been holding steady in the last 30 years (Moffatt and Nichol et al. 1987).

The tidal marshes in the central portion of the South San Francisco Bay (i.e., north of the Dumbarton Bridge) are expected to suffer significant loss of sediment in the next 50 years (Moffatt and Nichol et al. 1987). The South San Francisco Bay south of Dumbarton Bridge has a substantial acreage of tidal marsh and diked wetland where sedimentation appears to be keeping up with the increase in RMSL, so the tidal coverage of many of the tidal marshes has been relatively stable. The same marshes, however, have been extensively backfilled and have undergone major changes in vegetation due to subsidence and changes in salinity, the latter due to increased sewage outflows (Shellhammer 1982; Shellhammer et al. 1988). It is not clear whether these marshes will persist under these projected conditions by the U.S. EPA (1983), NRC (1987), or Moffatt and Nichol et al. (1987), or whether they will continue to support mice as vegetation continues to change. That uncertainty places much more importance on the diked wetlands that surround them and on the marshes of the central portion of the South Bay.

The Diked Marshes of the South San Francisco Bay

While some of the diked marshes of the South San Francisco Bay have been shown to support small to occasionally large populations of salt marsh harvest mice (Shellhammer et al. 1989), they and the salt ponds of the region have undergone substantial subsidence ranging from 0.6 to 1.0 m (2 to 3 ft.) (Moffatt and Nichol et al. 1987). Rainwater and occasional flooding by tidal water flood diked marshes, so salt accumulates in the soil. Moffatt and Nichol et al. (1987) indicate that saltier conditions lead to the degradation of the salt marsh vegetation and a consequent loss of wildlife habitat value. Zetterquist (1978), Shellhammer (1982), and Shellhammer et al. (1982, 1989) have shown, however, that such salty conditions are preferred by salt marsh harvest mice and that they use the saltiest pickleweed when high populations of meadow mice are present (Geissel et al. 1988). Hence, while it is possible that the overall wildlife values of diked marshes may decline with subsidence, they maintain their value for salt marsh harvest mice unless they flood or become dried out for long periods of time (Shellhammer et al. 1982, 1989). They constitute a major portion of the remaining habitat of the *R. r. raviventris* subspecies at present, and it appears that they will constitute the majority of its habitat if RMSL rise continues, especially at the rates predicted by the U.S. EPA (1983) and NRC (1987). They obviously will be lost if filled and developed.

Perhaps not so obviously, the diked marshes will also disappear if their outboard levees are not heightened and maintained, because most of them have subsided or compacted so much that they will revert to open water or mud flats if exposed to tidal action (Moffatt and Nichol et al. 1987) (Fig. 2). Since the costs of heightening outboard levees will be great, it is likely that private landowners and the cities and counties bordering the Bay will undertake economic "triage" when threatened with rising sea levels and protect developed areas to the detriment of undeveloped, diked marshes. They may, however, grant protection to large, consolidated areas of diked salt marshes set aside as salt marsh harvest mouse reserves. Small, disjunct, diked marshes, however, are unlikely to be protected as part of such triage. Thus, relative mean sea level changes and selective dike maintenance will change the management practices of the salt marsh harvest mouse, especially in the South Bay.

Shifts in Management of the Mouse

The U.S. Fish and Wildlife Service (USFWS), the California Department of Fish and Game, and others have been able to acquire and protect some marshes in the range of the *halicoetes* subspecies. Some of these acquisitions have been made as mitigation for other marshland development and have been added to wildlife areas and other federal agency lands. Land costs are high everywhere in the San Francisco Bay area but relatively lower on the north side of San Pablo Bay and in the Suisun Bay; hence, acquisition of off-site properties for mitigation is sometimes possible.

Similar mitigation activities, however, are seldom possible within the range of the *raviventris* subspecies, that is, primarily in the South San Francisco Bay. In this area, marshland is being offered speculatively at $140,000 to $700,000/hectare ($60,000 to $275,000/acre). Hence most of the marshland in the range of *raviventris* is too costly to provide developers and government agencies with off-site habitat replacement. Furthermore, the creation of new habitat is largely experimental and entails too much risk to be universally accepted by regulatory agencies. In addition, the Recovery Plan does not advocate development of existing habitat in the hopes of securing large blocks of restorable habitat through a mitigation-bank approach. The Recovery Plan calls for the acquisition of large blocks of marshland with public dollars, such as allocations by Congress through the Land and Water Conservation Fund, publicly financed bond initiatives, etc. Exorbitant land costs obviously preclude a mitigation bank approach, apparently leaving public acquisition as the only recourse. Hence the USFWS seems to have little flexibility in carrying out the requirements of the Recovery Plan.

Since 1983 most permit applications have been denied for proposed commercial developments in wetlands throughout the South San Francisco Bay, not only because mitigation is difficult but because filling wetlands for non-water-dependent projects is contrary to numerous laws and regulations of state and federal resource agencies. The proximate result of blocked development is to protect existing habitat. At the same time, management of private lands is unlikely because they lie outside the jurisdiction of federal and state agencies, and most private landowners are unwilling to enhance endangered species values because this could reduce the commercial development values of their property. The unplanned ultimate strategy, however, may turn out to be ineffective in that not enough large, *unfragmented* areas of marsh may be protected in the future. In other words, Level 9 protection may not be provided to a number of sites within the range of the *raviventris* subspecies in the South Bay.

Alternatively, if regulatory agencies continue to block development on appropriate biological and legal grounds, one side effect might be that the high speculative real estate prices may fall to much lower levels. Many of the diked marshes might become potentially affordable to government agencies for purposes of marsh restoration or to developers needing off-site mitigation opportunities. However, if major developments do take place, speculative costs may continue to be so high as to hinder mitigation activities.

Hence, the agencies charged with protecting the mouse must act proximately and protect as much wetland and mouse habitat as possible. The marketplace always acts proximately; that is one reason there is government — to provide for the possibility of an ultimate strategy such as a Recovery Plan. The agencies resist development and are often administratively, legally, or fiscally prevented from creating large units of marshes by allowing the development of others. Realistically, there are only two large blocks of potentially restorable habitat in the South San Francisco Bay, the diked marshes already discussed and the salt ponds owned by the Leslie Salt Company. It is unlikely that extensive marsh restoration will be possible on the latter lands until salt production is greatly curtailed or abandoned. Rising sea levels may ultimately increase Leslie Salt's levee maintenance costs to a point where salt production is no longer feasible. At that point, thousands of acres of historic baylands will become available to the public sector within the San Francisco Bay National Wildlife Refuge, and it may be possible to purchase other ponds with public monies at more reasonable prices. At that point, however, it will be questionable if many of the ponds can be opened to the Bay and still be managed as tidal salt marshes because the rise in sea level and subsidence of the diked ponds may result in opened ponds becoming part of the Bay for decades rather than part of the shore. If the salt company cannot bear the expense of maintaining tens of miles of outboard dikes at that time, it is unlikely that the government will be able to do so either. The existing diked wetlands again appear to be the key element in the recovery of the mouse.

What development of diked marshes does occur should involve extensive on-site mitigation as part of the mitigation package. Water management systems — possibly pumps and certainly perpetual funding for future management — are of vital importance. Such enhancements will not only help the mice of a particular marsh in the long run, they will increase its value for future protection when economic triage is contemplated in the future and outboard dikes need to be raised by public agencies.

The already subsided South San Francisco Bay is not the only area that will be influenced by mean relative sea level changes. The San Pablo and Central San Francisco bays appear to have had the lowest rate of change in relative mean sea level in the past 50 years (Moffatt and Nichol et al. 1987), but many existing and potential marshes also occur in areas of subsidence. For example, most of the salt ponds and agricultural islands in the Napa Marshes along the north portion of San Pablo Bay (Fig. 1) will have to be managed as diked marshes if they are managed as mouse habitat, since they have undergone a great deal of subsidence since they were removed from tidal action. Most of the salt marshes along the Marin Peninsula and the large Petaluma Marsh are at risk from rising sea level and may require diking to survive a rapid rise in sea level, especially if it is greater than predicted by Moffatt and Nichol et al. (1987).

Hence it appears that much of salt marsh harvest mouse's habitat in the year 2037 will be managed diked marsh squeezed between highly developed urban areas and the rising bay. Tidal marshes may disappear for long periods of time, and it may not be possible to recreate them due to the prohibitive expense involved. Diked marsh reserves can be created from the present tidal marshes within the range of the northern subspecies, but only from the band of diked marshes within the range of the southern subspecies. There is no other place to go. The number and size of reserves established depends on future research to determine minimum genetically effective population size and the calculus of management and development events of the near future. At least five large, Level 9 reserves should be established within the range of each subspecies. Such reserves should be distributed throughout the range of each subspecies to maintain the clinal variation present in the species.

Much more must be learned soon about how to manage large diked areas. Our attention in the past has focused on tidal marshes that now appear to be potentially all too ephemeral. The importance of diked marshes to the survival of the salt marsh harvest mouse, especially the *raviventris* subspecies, is being recognized and will surely be reflected in the first revision of the recovery plan. Such a shift in emphasis will bode well for the mouse but not for the rail, since the rail depends on tidal marshes. This shift, if made, would reduce the chances of accomplishing the larger goal of the recovery plan — conserving large parts of the Bay/Delta marsh ecosystem. The mouse will be protected, but habitat diversity may be lost, and if that occurred the rail would disappear from many areas.

It is a paradox that government ecologists and federal wildlife agencies charged with the ultimate protection of endangered species are constrained by law, resources, and the marketplace and often have to act in a relatively proximate manner. Such conflicts, however, are inherent to our form of government. The paradox is acute in the case of the relative mean sea level changes and salt marsh harvest mouse in the San Francisco Bay region. Similar relative sea level rises will test the abilities of governmental agencies to protect endangered species and their wetland habitats along the coasts of the United States and the world in the near future.

Literature Cited

Broecker, W. S. 1987. Unpleasant surprises in the greenhouse? Nature **328**:123–126.

Fisler, G. F. 1963. Effects of salt water on food and water consumption and weight of harvest mice. Ecology **44**:604–608.

Fisler, G. F. 1965. Adaptations and speciation in harvest mice of the marshes of San Francisco Bay. University of California Publications in Zoology **77**:1–108.

Geissel, W. H., H. S. Shellhammer, and H. T. Harvey. 1988. The ecology of the salt marsh harvest mouse (*Reithrodontomys raviventris*) in a diked salt marsh. Journal of Mammalogy **69**:696–703.

Harvey and Stanley Associates, Inc. 1980. *Study of the salt marsh harvest mouse in Suisun Bay, California.* Report to U.S. Department of Interior, Water and Power Resources Services, Stockton, California. 52 pp.

Jones and Stokes Associates, Harvey and Stanley Associates, and John Blayney Associates. 1979. Protection and Restoration of San Francisco Bay Fish and Wildlife Habitat. Volume 1. U.S. Fish and Wildlife Service and California Department of Fish and Game, Sacramento, California.

Krone, R. B. 1979. Sedimentation in the San Francisco Bay system. Pages 85–96 *in* T. J. Conomos, editor. *San Francisco Bay, the Urbanized Estuary.* Pacific Division, American Association for the Advancement of Science, San Francisco, California.

Moffatt and Nichol, Engineers; Wetland Research Associates, Inc.; and San Francisco Bay Conservation and Development Commission Staff. 1987. Future sea level rise: predictions and implications for San Francisco Bay. Report to San Francisco Bay Conservation and Development Commission, San Francisco, California. 98 pp.

National Research Council. 1987. Responding to Changes in Sea Level, Engineering Implications. National Academy Press, Washington, D.C.

Nelson, K., R. J. Baker, H. S. Shellhammer, and R. K. Chesser. 1984. Test of alternate hypotheses concerning the origin of

Reithrodontomys raviventris: genetic analysis. Journal of Mammalogy **65**:668–673.

Peters, R. L., and J. D. S. Darling. 1985. The greenhouse effect and nature reserves. Bioscience **35**:707–717.

Poland, J. F., and R. L. Ireland. 1985. Land subsidence in the Santa Clara Valley, California, as of 1980. United States Geological Service Open File Report, Sacramento, California. pp. 814–818.

Rice, V. 1974. The population ecology of the salt marsh harvest mouse at Triangle Marsh. San Jose State Univ., San Jose, California. 102 pp. Master's thesis.

Schonewald-Cox, C. M. 1983. Conclusions: guidelines to management: a beginning attempt. Pages 415–445 *in* C. M. Schonewald-Cox, S. M. Chambers, B. MacBryde, and L. Thomas, editors. Genetics and Conservation. Benjamin/Cummings, Menlo Park, California.

Shellhammer, H. S. 1982. *Reithrodontomys raviventris.* Mammalian species (American Society of Mammalogists) No. **169**:1–3.

Shellhammer, H. S., R. Duke, H. T. Harvey, V. Jennings, V. Johnson, and M. Newcomer. 1989. Salt marsh harvest mice in the diked salt marshes of southern San Francisco Bay. Wasmann Journal of Biology (in press).

Shellhammer, H. S., R. Jackson, W. DaVilla, A. M. Gilroy, H. T. Harvey, and L. Simons. 1982. Habitat preference of salt marsh harvest mice (*Reithrodontomys raviventris*). Wasmann Journal of Biology **40**:102–114.

U.S. Environmental Protection Agency. 1983. Projecting future sea level rise. U.S. Government Printing Office, Washington, D.C. Report No. 230-09-007.

U.S. Fish and Wildlife Service. 1984. Salt marsh harvest mouse and California clapper rail recovery plan. U.S. Fish and Wildlife Service, Portland, Oregon. 141 pp.

Williams, P. B. 1985. An overview of the impact of accelerated sea level rise on San Francisco Bay. Report for the San Francisco Bay Conservation and Development Commission. San Francisco, California, 1985. 25 pp.

Wilson, E. O. 1975. Sociobiology, The New Synthesis. Belknap Press of Harvard Univ. Press, Cambridge, Massachusetts.

Zetterquist, D. K. 1978. The salt marsh harvest mouse (*Reithrodontomys raviventris raviventris*) in marginal habitats. Wasmann Journal of Biology, **35**:69–76.