Studies in Avian Biology No. 32:198–204

ARE SOUTHERN CALIFORNIA'S FRAGMENTED SALTMARSHES CAPABLE OF SUSTAINING ENDEMIC BIRD POPULATIONS?

ABBY N. POWELL

Abstract. Loss of coastal saltmarshes in southern California has been estimated at 75–90% since pre-settlement times. The remaining wetlands are mostly fragmented and degraded, and most frequently have harsh edges adjacent to urban landscapes. Non-migratory Belding's Savannah Sparrows (*Passerculus sandwichensis beldingi*) and Light-footed Clapper Rails (*Rallus longirostris levipes*) are endemic to saltmarshes in southern California and Baja California, Mexico. Population sizes of Belding's Savannah Sparrows show a positive relationship with saltmarsh area, but few large wetland fragments remain within their range in California. Belding's Savannah Sparrows are sensitive to fragmentation and isolation, with small isolated marshes acting as population sinks. In addition, this subspecies shows low genetic variability, limited dispersal, and small effective population sizes. Light-footed Clapper Rails are habitat specialists, found in marshes with good tidal flushing that support California cordgrass (*Spartina foliosa*) habitats. Light-footed Clapper rails also show low genetic variability and limited dispersal and the remnant populations of clapper rails are relatively isolated from one another. Large wetland complexes may serve as population sources for both species, while small, isolated marshes may act as population sinks but more research is needed to estimate and model the dynamics of these two metapopulations. Mitigation for wetland loss and restoration projects should not be evaluated simply by presence of rare bird species alone, but instead efforts should be made to determine population sustainability.

Key Words: Belding's Savannah Sparrow, California, fragmentation, Light-footed Clapper Rail, metapopulation, saltmarsh.

SON CAPACES DE SOSTENER LAS MARISMAS DE MAREA FRAGMENTADOS DE CALIFORNIA POBLACIONES DE AVES ENDÉMICAS?

Resumen. La pérdida de las marismas de marea costeros en el sur de California ha sido estimada en un 75–90% a partir de los tiempos de pre-colonización. Los humedales que aun quedan se encuentran en su mayoría fragmentados y degradados, y con frecuencia sus bordes se encuentran adyacentes a paisajes urbanos. Los Gorriones Sabaneros No-migratorios (*Passerculus sandwichensis beldingi*) y el Rascón Picudo de Patas Ligeras (*Rallus longirostris levipes*) son endémicos en las marismas de marea en el sur de California y en Baja California, México. Los tamaños de las poblaciones de Gorriones Sabaneros muestran una relación positiva con el área de marisma salada, pero quedan pocos fragmentos largos de humedales dentro de su rango en California. Los Gorriones Sabaneros son sensibles a la fragmentación y al aislamiento, con pequeños marismas aisladas actuando como resumideros de población. Además, esta subespecie muestra variabilidad genética baja, limitada dispersión, y pequeños tamaños de población efectiva. Los Rascones Picudos de Patas Ligeras son especialistas del hábitat, encontrados en marismas con buena nivelación de marea, la cual mantiene habitats de pasto (*Spartina foliosa*). Los Rascones Picudos de Patas Ligeras también muestran baja variabilidad genética y limitada dispersión, y las poblaciones remanentes de Rascones Picudos se encuentran relativamente aisladas una de otra. Complejos de largos humedales quizás sirvan como fuentes de población para ambas especies, mientras que marismas pequeñas y aisladas quizás actúen como resumideros de población, pero se necesita más investigación para estimar y modelar las dinámicas de estas dos meta poblaciones. La mitigación para la pérdida de humedales y proyectos de restauración no deberían de ser evaluados simplemente por la presencia de aves raras por si solas, si no que los esfuerzos deberían hacerse para determinar la sustentabilidad de la población.

More than 16,000,000 people live along southern California's coast and the impact of a dense human population, coupled with high endemic biodiversity, has resulted in the listing of numerous species as threatened and endangered (Davis et al. 1995). Southern California's saltmarshes have suffered significant habitat degradation and loss of area. California has lost an estimated 91% of all wetlands and about 75% of its coastal wetlands since pre-settlement (Zedler 1982, Macdonald 1990). Estuarine systems in southern California have been highly altered by urban development, filling, river channelization, changes in freshwater flow, and invasion of exotic species. Marshes have become more and more isolated by the expansion of urban areas creating hostile environments for dispersing organisms. Isolation can hinder emigration, immigration, and gene flow (Shafer 1990, Andren 1994). Habitat fragments

may become sinks ecological traps for some animal populations if production of young fails to exceed mortality, and local extinctions may occur unless immigration occurs from source habitats (Pulliam 1988, Howe et al. 1991).

Western saltmarshes provide nesting habitat for several rare species, including Belding's Savannah Sparrow (*Passerculus sandwichensis beldingi*) and Light-footed Clapper Rail (*Rallus longirostrus levipes*). Salt-pan habitats located within coastal marshes provide nesting sites for endangered California Least Terns (*Sterna antillarum browni*) and threatened Western Snowy Plovers (*Charadrius alexandrinus nivosus*), while channels and mudflats provide foraging habitat for these species. These marshes also provide important wintering grounds and foraging areas for migratory shorebirds and waterfowl.

The Belding's Savannah Sparrow was listed as endangered by the state of California in 1974 and the Light-footed Clapper Rail was listed as federally endangered in 1970 (USDI Fish and Wildlife Service 1979). Both subspecies are endemic to saltmarshes in southern California and Baja California, Mexico, and have suffered significant population declines due to wetland loss and degradation (Zembal et al. 1988, Massey and Palacios 1994).

Avian diversity within freshwater and brackish marshes has been attributed to marsh size, diversity of habitat types, amount of open water and degree of isolation from similar habitats (Kantrud and Stewart 1984, Brown and Dinsmore 1986, Peterson et al. 1995). Studies of avian abundance in coastal wetlands have typically focused on habitat use in the eastern US (Burger et al. 1982, Marshall and Reinert 1990, Erwin et al. 1995). Few studies have presented quantitative data on habitat use by birds of western coastal saltmarshes that have suffered considerable loss and degradation, particularly in coastal southern California. Even fewer studies exist on saltmarsh bird populations in adjacent Mexico. Here, I review the information available for two species endemic to southern California saltmarshes with respect to their sustainability within the US.

SOUTHERN CALIFORNIAN SALTMARSHES

Three littoral zones that have varying degrees of overlap in composition of vegetation types typically characterize saltmarshes in southern California. Low-marsh habitats occur in the lowest elevation and experience tidal inundation twice a day. California cordgrass (*Spartina foliosa*) is the dominant low-marsh species in marshes with full tidal flushing (access to tides has not been restricted by sedimentation or channelization) (Zedler 1982). In intermediate elevations, mid-marsh habitats have higher species diversity and are dominated by pickleweed (*Salicornia virginica*), which is tolerant of high soil salinities and inundation by salt and fresh water (Zedler 1982, Keer and Zedler 2002). Highest elevations in the marsh have the driest soils and highest soil salinities. The high-marsh zones are typically dominated by the Parish's pickleweed (*Salicornia subterminalis*; Zedler 1982). Loss of tidal circulation not only reduces the likelihood of cordgrass habitats, but also tends to decrease plant species diversity; monocultures of pickleweed are often found in these marshes (Zedler 1982). Considerable research has occurred on the restoration of these habitats in southern California saltmarshes (Zedler 1996, Zedler et al. 2001, Keer and Zedler 2002).

BELDING'S SAVANNAH SPARROW

Belding's Savannah sparrows are non-migratory and endemic to southwestern saltmarshes, ranging from Goleta Slough in Santa Barbara County southward to Bahia de San Quintin, Baja California, Mexico (Fig. 1). Within the US, their southernmost local population occurs at Tijuana Estuary and they have been documented breeding in 30 marshes ranging from <1 ha to approximately 620 ha in size ($\bar{x}$ = 92.9 ± 136 ha; Fig. 2). This subspecies of Savannah Sparrow (*Passerculus sandwichensis*) is generally associated with *Salicornia* spp. habitats in mid- (dominated by pickleweed to high (dominated by Parish's pickleweed) littoral zones and avoids areas prone to frequent tidal inundation (Powell 1993, Powell and Collier 1998). In most remnant marshes, pickleweed habitats have been degraded by changes in tidal flow and freshwater inputs, invasion of non-indigenous plants, and fragmentation by trails and roads. Connections to native habitats beyond the high-marsh zone are rare in southern California and frequently this habitat type is adjacent to an urban interface; therefore use/importance of native uplands by these sparrows is unknown. Belding's Savannah Sparrows are rarely observed outside of saltmarsh habitats and are more frequently observed on adjacent beaches than uplands (Bradley 1973, Massey 1979; Powell, unpubl. data).

Volunteers have conducted censuses of Belding's Savannah Sparrows in southern California approximately every 5 yr since 1986. Counts occurred in 26–30 coastal saltmarshes and effort varied among wetlands and years. All 30 marshes were surveyed in 1986, 1991, 1996, and 2001, and the total estimated number of breeding pairs in California was 1,844–2,902

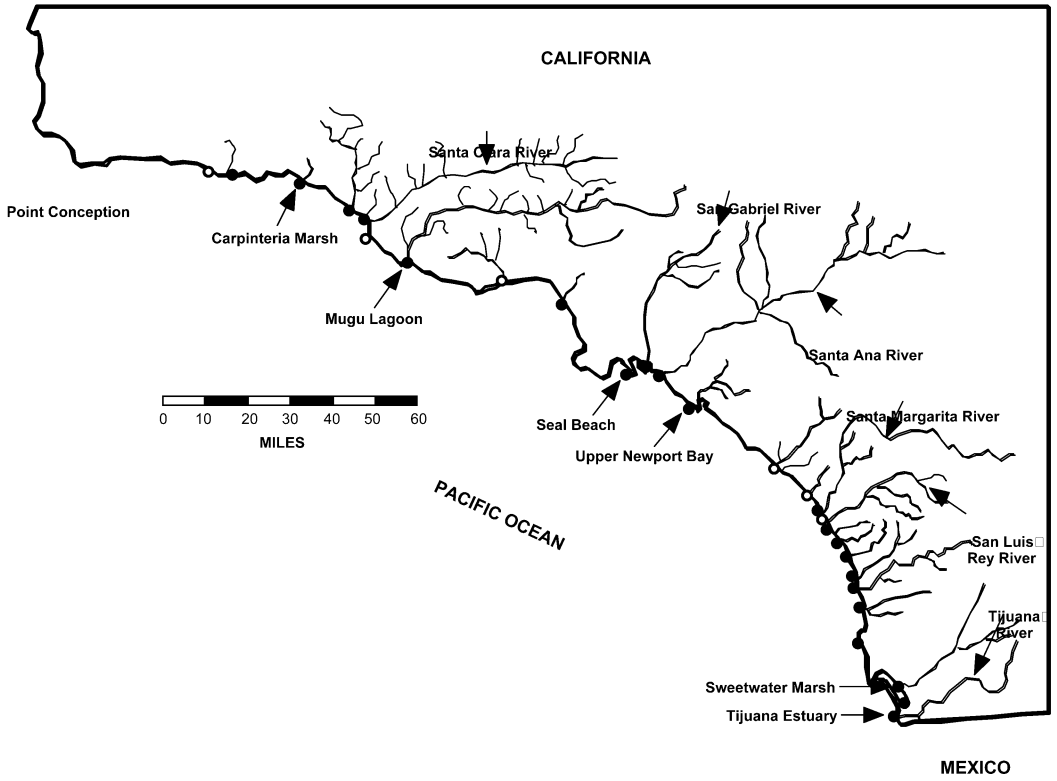

FIGURE 1. Map of coastal marshes in southern California. Dark circles are those marshes occupied by Belding's Savannah Sparrows.

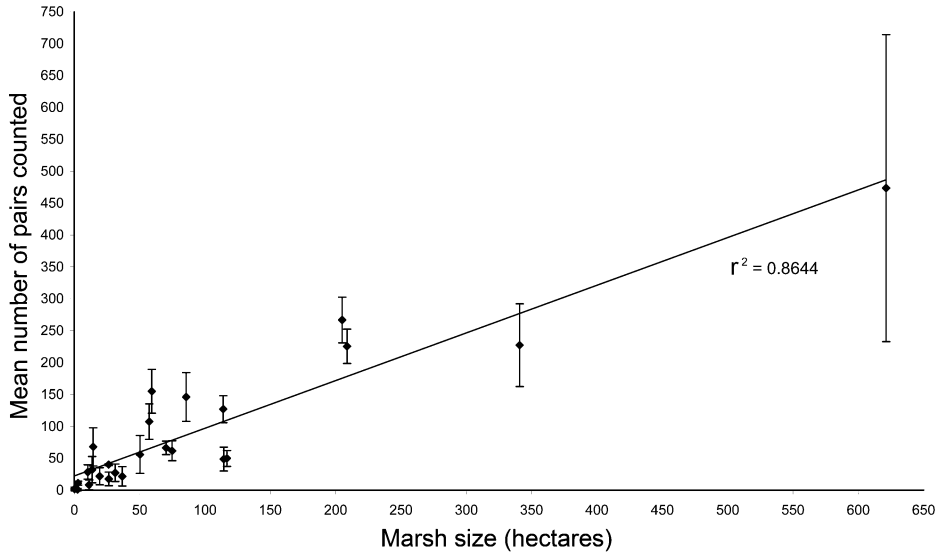

FIGURE 2. Relationship of Belding's Savannah Sparrow counts (1986–2001) to marsh area (hectares) in southern California.

(Zembal et al. 1988, Zembal and Hoffman 2002). Mugu Lagoon, the largest saltmarsh (620 ha) in southern California, consistently supported the largest local population of sparrows, followed by Tijuana Estuary (205 ha), Upper Newport Bay (208 ha), and Seal Beach (340 ha; Fig. 3). Data from these counts show that like grassland Savannah Sparrows, Belding's Savannah Sparrows are area sensitive; a positive relationship exists between size of wetland and indices of local population size, and sparrows are unlikely to occur in marshes <10 ha in size (Fig. 2; Powell and Collier 1998).

Work on breeding biology of Belding's Savannah Sparrows at Carpinteria Marsh, Santa Barbara County, California, indicated that effective population size is likely much smaller than the total population; <50% of males established territories and only 43% of those males managed to attract mates (Burnell 1996). The males that were unable to establish territories were considered to be floaters. In her 3-yr study, Burnell estimated that the effective population size ranged from 12–35% of the total population size during 1991–1993. She also determined that 33% of the males at Carpinteria were polygynous, with each male paired with two females within a territory. Within the Sweetwater Marsh complex, San Diego County, California, 93% of territorial males attracted mates and 9% of males were polygynous (Powell and Collier 1998). Powell and Collier (1998) did not know the total population of Sweetwater Marsh and therefore could not estimate the percentage of floaters. The discrepancy in the number of territory holders without mates between the two studies may partially be an artifact of sampling; the Powell and Collier (1998) was intensive (a total of 216 hr observing 54 territories during one breeding season), whereas Burnell's (1996) study was extensive (a total of 206 hr spread over 3 yr observing a total of 49 territories). Females are very difficult to observe because of their secretive behaviors, thus Burnell may have overestimated the number of males that failed to attract mates. Regardless, it should be noted that effective population size is likely to be a fraction of the number of sparrows present in a marsh.

Belding's Savannah Sparrow has limited dispersal and is a metapopulation with extirpation

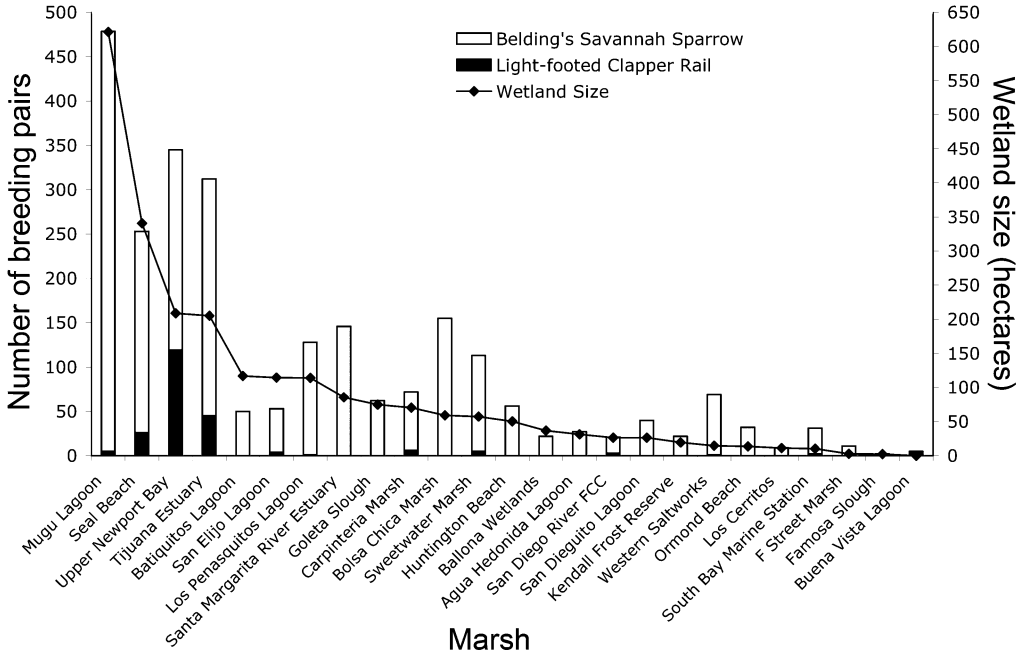

FIGURE 3. Relationships of Belding's Savannah Sparrow (average of four counts between 1986–2001) and Light-footed Clapper Rail (average of annual counts from 1980–2002) populations to marsh area (hectares) in southern California. Total marsh area decreases from left to right and overestimates the actual amount of saltmarsh habitat because areas were estimated using National Wetland Inventory E2 classification data (<http://www.nwi.fws.gov/> [31 July 2006]).

and recolonization of local populations (Zembal et al. 1988, Bradley 1994, Burnell 1996, Powell and Collier 1998). Bradley (1994) and Burnell (1996) found that local populations had distinct song dialects. In addition, Burnell (1996) found genetic evidence that little or no gene flow occurs among local populations of Belding's Savannah Sparrows and that allozyme differentiation among populations was most likely caused by genetic drift. Local populations of Belding's Savannah Sparrows in seven of the marshes she surveyed between Santa Barbara and San Diego counties had lower heterozygosity than expected in a Hardy-Weinberg equilibrium and there was also evidence of inbreeding within these populations (Burnell 1996).

In 1995, I established six study plots to examine reproductive success of Belding's Savannah Sparrows within the Sweetwater Marsh complex in San Diego County, California (Powell and Collier 1998). These marshes are highly fragmented and surrounded by urban and industrial landscapes. Plots were located in mid- and high-marsh habitats (Powell 1993). Comparisons of reproduction among plots showed significant differences between high reproductive success in high-marsh plots within the largest marsh (50.6 ha) and low reproductive success at the small isolated marsh (2.9 ha), where no fledglings were produced over the breeding season. The small marsh was isolated from other marsh habitats and surrounded completely by an urban landscape. In addition, despite the fact that this marsh was located only 0.5 km from the larger marsh, no movements of banded birds were observed between them, indicating exchange rates may be quite low.

I also examined the effects of habitat on reproductive success and found that areas with the tallest, densest vegetation and low quantities of bare ground were the best predictors of high-success (those that produced fledglings) territories. I found no relationship between territory size and reproductive success. Few of the study plots, with the exception of the small isolated marsh, had much space unoccupied by territories except for those areas with a high proportion of bare ground. Most of the vegetated areas consisting of mid- and high-marsh plant species were occupied by territories throughout the breeding season, suggesting that suitable nesting habitat was limited. Finally, I also banded 277 sparrows prior to the breeding season at Sweetwater Marsh in 1995 and did not see any of them at any other marsh within the San Diego Bay area in 1995 or following years (1995–1997). In addition, 45.5% of banded males within our plots occupied the same territories the following year, suggesting little emigration and high site fidelity. In summary, my research on reproductive success of Belding's Savannah Sparrows in different-sized wetlands within San Diego Bay suggested that small, isolated saltmarshes supported breeding birds but functioned as population sinks because they supported little or no productivity (Powell and Collier 1998).

Light-footed Clapper Rail

The Light-footed clapper rail is a year-round resident of saltmarshes from Tijuana Estuary on the Mexican border, north to Santa Barbara County within the US, and like Belding's Savannah Sparrows, extends south to Bahia de San Quintin, Baja California, Mexico. Unlike Belding's Savannah Sparrows, Light-footed Clapper rails are closely associated with low-marsh habitats, particularly those consisting of cordgrass (Massey et al. 1984). This habitat type is associated with marshes with good tidal flushing and has disappeared from those marshes, such as Mugu Lagoon, with decreased tidal flow due to sedimentation, dredging, and river channelization. Only a small subset of southern California's saltmarshes currently supports cordgrass habitats: Tijuana Estuary, Sweetwater Marsh, Upper Newport Bay, and Seal Beach (Fig. 1; Zedler 1982).

Studies on the movements of Light-footed Clapper Rails indicate that they have strong site tenacity and rarely move >400 m; the farthest documented movement is 21.7 km (Zembal et al. 1989). In addition, genetic analysis of the subspecies indicated there was low genetic variability and reduced heterozygosity within Light-footed Clapper Rails (Fleischer et al. 1995). This subspecies shows a classic metapopulation structure, with local populations that experience extinction, recolonization, and limited dispersal (Fleischer et al. 1995, Zembal et al. 1998).

Light-footed Clapper Rails have been monitored annually in California since 1980. Marshes that potentially support clapper rails are visited in spring, and clapper rail calls are counted. Clapper rails use several distinct calls during the breeding season that can be used to distinguish single males, single females, and mated pairs (Massey and Zembal 1987). During a census, people walk slowly through the marsh at dawn or dusk and mark locations of calls on a map. In addition, taped calls may be played to elicit responses (Zembal 1998). Each year a breeding survey report is submitted to the California Department of Fish and Game. In 1980, the first year of the survey, the Light-footed Clapper

Rail metapopulation consisted of an estimated 203 breeding pairs; a high of 325 breeding pairs was counted in 1996 (Zembal et al. 1998). The number of estimated pairs has varied around the 22-yr mean of 231 pairs, but no overall pattern of decline or increase has occurred during this period. Upper Newport Bay consistently supported >50% of California's Light-footed Clapper Rails, and three sites combined (Upper Newport Bay, Tijuana Estuary, and Seal Beach) supported >80% of breeding pairs in any given year. These three estuaries are the second, third, and fourth largest in size within the range of the Clapper Rail (Fig. 3), Upper Newport Bay is relatively isolated from other saltmarshes in the region, and all three marshes are isolated from each other (Fig. 1). Mugu Lagoon, the largest wetland, supported on average only four pairs of rails, but this site has very little cordgrass habitat. Of the remaining 21 marshes where Light-footed Clapper Rails are found, none supported >4% of the metapopulation, and 15 each supported <1% of the metapopulation (usually one bird per wetland).

In addition to limited availability of cordgrass habitats in southern California, Light-footed Clapper Rail populations have been negatively impacted by predation. Removal of non-native red foxes (*Vulpes vulpes*) resulted in growth of the local population at Seal Beach from a low of five pairs in 1986 to a high of 65 pairs in 1993 (Zembal et al. 1998). In addition to predator management, nesting rafts were used at this site to increase nest site availability since the late 1980s. Recently however, the local population at Seal Beach appears to be lower (range = 10–24 pairs, $\bar{x}$ = 15.2; 1998–2002) than in the 1990s (range = 28–66 pairs, $\bar{x}$ = 43.9; 1990–1997; Zembal, unpubl. data). It is postulated that nesting rafts may actually increase rates of predation by raptors (Zembal et al. 1998).

DISCUSSION

It is clear that amounts of saltmarsh habitats, including pickleweed but in particular cordgrass, are currently limited in southern California. The remaining saltmarshes are mostly degraded to some extent and changes in tidal influence have eliminated the occurrence of cordgrass habitats in many marshes. In addition to degradation caused by changes in the hydrological regime, saltmarshes in southern California are typically surrounded by urban and/or industrial landscapes (Fig. 1). This creates a hostile environment for dispersal and likely causes naturally isolated wetlands to become functionally even more isolated. Neither Belding's Savannah Sparrows nor Light-footed Clapper Rails are thought to be good dispersers, and decreases in already low natural rates of immigration and emigration can have significant impacts on local population viability. Reduced dispersal can lead to local extinctions, reduced genetic variability, inbreeding depression, and decreased colonization rates (Pulliam 1988, Andren 1994).

Increased rates of predation related to human activity are another form of habitat degradation. Some predators, like red foxes, are not native to southern California but have become problematic as their populations have increased. Non-native red foxes have expanded their ranges and populations in California and impact coastal ecosystems, particularly Light-footed Clapper Rail populations (Zembal et al. 1998, Lewis et al. 1999). Common Ravens (*Corvus corax*), known predators of eggs, nestlings, and even adult birds, have increased substantially in California since the 1960s (Boarman and Berry 1995). Likewise, the proliferation of feral and domestic cats (*Felis catus*) in urban areas has a significant impact on native birds, and cats are frequently observed in these saltmarshes (Ogan and Jurek 1997). Increased rates of predation likely reduce survival rates of adults and young, and increase mortality during dispersal.

Although it is unlikely that new estuaries can or will be created in this region, it is possible to improve and expand cordgrass coverage in existing marshes. Foin and Brenchley-Jackson (1991) suggested that cordgrass habitat improvement within existing marshes could potentially triple the rail population, however restoration of saltmarsh vegetation can be a long and expensive process (Zedler et al. 2001). Despite the severe limitation of cordgrass habitat, captive breeding and reintroduction efforts have been initiated for Light-footed Clapper Rails (California Department of Fish and Game, unpubl. data). It has been well documented that the key predictors of successful translocations are habitat quality and the quality and number of animals released. In general, endangered species translocations are unsuccessful >50% of the time and if animals are released into habitats that are in poor condition or have insufficient area they are unlikely to persist (Griffith et al. 1989, Wolf et al. 1998). In addition, although Fleischer et al. (1995) suggested that translocations of Light-footed Clapper Rails could increase the genetic variability within local populations, they cautioned that documentation must first show that inbreeding depression is problematic for this species. Finally, more information is needed on natural recruitment into local populations of Light-footed Clapper

Rails. Given the small number of Light-footed Clapper Rails remaining in southern California and the limited and degraded condition of estuarine habitat, efforts to increase local populations should emphasize habitat creation and enhancement rather than costly translocations with low potential for success.

Restoration of high-marsh zones dominated by pickleweed is also possible. Degraded pickleweed habitats can be enhanced by restoring natural hydrological regimes, and the dominant species of pickleweed (*Salicornia virginica*), recruits readily (Zedler et al. 2001). Restoration of plant diversity in mid- to high-marsh zones increases vegetation structural diversity, which in turn may provide an increased prey base for Belding's Savannah Sparrows (Keer and Zedler 2002). Local populations of Belding's Savannah Sparrow have expanded after restoration efforts improved water flows at Mugu Lagoon (Zembal and Hoffman 2002).

Are the populations of Belding's Savannah Sparrows and Light-footed Clapper Rails in southern California sustainable? Given current information on low genetic variability, low dispersal rates, and low overall population sizes it seems questionable that either subspecies will persist unless more saltmarsh habitat is created and existing habitats are restored. More research is needed to determine and model the dynamics of these two metapopulations. Unfortunately, southern California's saltmarshes have not been characterized in relationship to habitat type, patch size and shape, connectivity, and isolation. Indeed, the amount of coverage by cordgrass and pickleweed-dominated habitats is unknown for most marshes. This information is critical, especially for the management of Light-footed Clapper Rails and Belding's Savannah Sparrows.

Both subspecies show metapopulation structure and should be managed as such. Planners and managers need to ask the following questions before designing habitat restoration and enhancement projects:

1. Is the existing wetland complex large enough to support self-sustaining local populations over time?
2. Are patches of specific habitat types (e.g., cordgrass or pickleweed) large enough to support self-sustaining local populations over time?
3. Are dispersers able to move between wetlands (will source or sink populations equilibrate over time)?
4. In a regional context, will the restoration benefit the metapopulation?

Finally, assessments of population size for each species need to consider that effective population size is likely a fraction of the total number of territorial birds counted.

We should take a regional approach to wetland restoration in order to enhance metapopulations of sparrows and rails. For example, unless overall wetland area is increased, creating cordgrass habitat to benefit Light-footed Clapper Rails may be at the expense of pickleweed habitats required for Belding's Savannah Sparrows and vice versa. Converting saltpan or dredged areas to saltmarsh may reduce the amount of habitat available to endangered California Least Terns, threatened Western Snowy Plovers, and other shorebirds that use these habitats. Considerations should be giving to the status of the target species, probability of success of habitat restoration, and overall ecosystem functioning.

ACKNOWLEDGMENTS

I thank C. Fritz and B. Peterson who worked with me in southern California's saltmarshes. I also thank J. Zedler as a mentor and for her tireless work to restore these wetlands. D. Zembal has graciously shared his data on Belding's Savannah Sparrows and Light-footed Clapper Rails, and it has been through his efforts that censuses of both species have continued through the years. B. Griffith provided valuable comments on this manuscript.