

MONITORING BANK SWALLOW POPULATIONS ON THE SACRAMENTO RIVER: A DECADE OF DECLINE

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ABSTRACT: In 1989, the California Fish and Game Commission listed the bank swallow (*Riparia riparia*) as a threatened bird species in accordance with the California Endangered Species Act. This action was based upon a California Department of Fish and Game (CDFG) petition that documented that the species had declined throughout its range within California, was extirpated from approximately 50% of its historic range (primarily in the southern part of the State), and faced further reduction in populations and habitat due to ongoing bank protection projects of the State Reclamation Board and the U.S. Army Corps of Engineers on the Sacramento River, Feather River, and major tributaries. Sacramento Valley riparian systems provide habitat for over 70% of the remaining population. Research conducted during the bank swallow breeding seasons in 1986 and 1987, followed by annual monitoring, established the scientific basis for the petitioned action that recommended listing of the species in 1989. Additional monitoring of the Sacramento River population of bank swallows has documented a serious decline since the 1986 baseline for population estimates. The 1996 breeding population of 5,770 pairs of bank swallows is only 44% of the 1986 estimate of 13,170 pairs. Many colony sites and eroding banks along the Sacramento River continue to be threatened by planned bank protection projects proposed for construction.

Key words: Bank swallow, bird numbers, California monitoring, *Riparia riparia*, Sacramento River

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The bank swallow (*Riparia riparia*) is a native migratory bird species that has declined in a significant portion of its range in California due to habitat destruction and human disturbance. Upon a recommendation from the CDFG, the species was listed as threatened in 1989 in accordance with the California Endangered Species Act (CESA). Beginning in 1986, bank swallow colonies on the Sacramento River have been monitored annually by the CDFG to document population trend and habitat condition. The goals of this research were to (1) determine if the bank swallow's population status warranted protection of the species under the CESA, and (2) continue a routine monitoring program to track the population trend.

Biology and Habitat Relationships

The bank swallow is the smallest of the North American swallows and is a colonial nester in lowland river banks and coastal bluffs (Bent 1939). It is distinguished from other swallows by its distinctive brown breast band contrasting against clean white underparts and dark brown upper parts. Sexes are monomorphic and cannot be separated by plumage characteristics. Bank swallows are migratory species spending the winter months in north-central South America (Rappole et al. 1983).

Bank swallows arrive on the breeding grounds along the banks of the Sacramento River in late March to April and begin courtship and pairing. When the nesting burrow is completed, a clutch of 3-5 white eggs is laid. On the Sacramento River, egg laying occurs as early as 10 April (Humphrey and Garrison 1987). Nestlings are fed insects by adults until they move out of the burrow,

fledge, and forage independently. By mid-July, most nesting activities are completed and the colony sites are abandoned and become overgrown with vegetation.

Bank swallows are relatively short-lived species with an average life span of 2-3 years with 5 years being exceptional. Mortality results from a number of causes including disease, parasites, and predation. On the Sacramento River, gopher snakes (*Pituophis melanoleucus*) constitute an important predator of eggs and nestlings, and raptors such as American kestrels (*Falco sparverius*) take recently fledged young and some adults (Humphrey and Garrison 1987). Collapsed burrows, due to natural or human-caused sloughing of banks or destruction of nest sites, is also a significant cause of direct mortality of young birds.

The food of bank swallows consists of various species of flying terrestrial and aquatic insects. Because they forage a few inches over water, they catch mayflies (*Ephemera*) and other aquatic insects just as they emerge from the nymphal stage (Bent 1939).

Hickling (1959) described 3 main types of bank swallow nesting sites: (1) sea cliffs or hard consolidated sand, (2) river banks of sand and sandy earth, and (3) active sand and gravel pits. On the Sacramento River, bank swallows nest in steep earthen banks that are subject to frequent erosion. These cut banks constitute a natural component in a cross section of the riparian zone (Strahan 1984).

Nest sites consist of burrows dug into the bank to a depth of 46-92 cm. Burrows are elliptical, about 5 cm high and 8 cm wide, and are most often found in soils that are fine sandy loam to loam in texture. After a

short courtship, both sexes actively dig the nest burrow into the side of banks that are generally vertical (90 degrees). Burrows remaining from a previous season may be used by a pair after some renovation. Burrows are located in colonies that may be relatively small (10 burrows) to quite large (3,000 burrows). Burrows are dug into selected strata of a bank face based on criteria such as soil moisture, texture, aspect of the bank face, verticality of the face, and proximity to foraging areas (Humphrey and Garrison 1987, Garrison 1991). Since 1986, an average of 45% of the available burrows have been occupied by breeding pairs (Garrison, unpubl. data). At the present time, Sacramento River stream banks are the most important and also appear to be the most threatened of all habitats bank swallows occupy in California (Garrison 1991, California Department of Fish and Game [CDFG] 1995).

The terrain immediately adjacent to colonies may be open grasslands or riparian forests, but grasslands are preferred for foraging. Environmental features of the breeding site are important for the survival and comfort of adults and young and also the activity of terrestrial and aquatic flying insect prey. The birds course low over grasslands and catch insects on the wing. The colony is the focus of all social and breeding activities of the bank swallow. Unique combinations of optimal features may dictate the size and success of individual colonies.

Status and Threat

The bank swallow is considered a riparian species throughout its North American and Eurasian breeding range. It is known as the sand martin in the Old World. Once locally abundant in lowland California (Grinnell and Miller 1944), bank swallow numbers have declined Statewide in recent years and it is absent as a breeding bird in southern California (Remsen 1978, Garrison et al. 1987, Humphrey and Garrison 1987, Laymon et al. 1988, CDFG 1995).

Remsen (1978) reported that reasons for the species' decline are unknown for coastal populations where breeding cliffs appear to be intact. However, he suggested that State and Federal bank protection programs employing the extensive use of rip-rapping of river banks have destroyed former inland nesting sites and other human disturbances threatened many colonies. In fact, Remsen (1978) stated that the channelization of rivers is the most "insidious" long-term threat to the bank swallow and that almost all colonies in the Sacramento Valley will be destroyed by planned bank construction projects by the U.S. Army Corps of Engineers. Humphrey and Garrison (1987) concluded that with almost 90% of the breeding pairs on the Sacramento River utilizing outside bends of the river to establish colonies,

any rip-rap of these areas would certainly pose a significant threat to the population. They went on to state that an examination of bank swallow distribution in the State yielded no other suitable habitat of the magnitude contained within the Sacramento River riparian system. Besides habitat loss, direct mortality of bank swallows from bank protection activities by responsible State and Federal agencies occurred in the mid 1980's.

Humphrey and Garrison (1987) recorded instances of direct and indirect human disturbance of colonies. They observed 3 instances of bank sloughing in May and June 1986, with some destruction of colonies probably due to bank under-cutting caused by high water releases from Shasta Lake or speed boats and water-skiing activities. A few colonies that were easily accessible had burrows disturbed by humans as evidenced by rocks and other debris apparently stuffed into the entrances. Additional causes of the population decline have been proposed including pesticides, loss of wintering habitat, and declines in prey populations (Garrison et al. 1987, Humphrey and Garrison 1987, Laymon et al. 1988, CDFG 1995).

Bank swallows spend the winter in north-central South America, where their primary wintering areas are grasslands, savannah, freshwater, and brackish wetlands. These wintering areas are undergoing destruction similar to that occurring with tropical rain forests (Rappole et al. 1983). Robbins et al. (1986) analyzed breeding bird survey data on bank swallow populations from 1965 to 1979 and found considerable variation in the annual counts, which made it difficult to detect long-term changes. A conservative analysis was conducted using the number of stops at which bank swallows were recorded, and Robbins et al. (1986) reported that population curves for the western, central, and eastern regions of the country were flat, indicating no significant population changes and that there is little apparent evidence to suggest declines in prey populations.

Three eggs collected from Sacramento River colonies and analyzed in 1986 contained pesticide residue levels far below those considered detrimental to hatching (CDFG files). The population decline and range constriction noted by Remsen (1978) and others prompted the Department to undertake a comprehensive study of the population distribution, status, and nesting ecology of the bank swallow in California during 1986 and 1987 (Garrison et al. 1987, Humphrey and Garrison 1987, Laymon et al. 1988).

STUDY AREAS

Data reported in this study were gathered by a number of researchers working under CDFG contracts or participating as staff or volunteers during CDFG led moni-

toring surveys conducted on the Sacramento River between 1986 and 1996.

In 1986 and 1987, the study area consisted of a reach of the Sacramento River from River Mile (RM) 81 near Verona to RM 292 near Redding (Garrison et al. 1987, Humphrey and Garrison 1987, Laymon et al. 1988).

Monitoring surveys during 1988-96 have concentrated in a reach of the Sacramento River from RM 81 to RM 243 near Red Bluff (CDFG 1995; Fig. 1). The study area is characterized by a broad, meandering river with remnants of a once extensive Central Valley riparian forest. River banks, extensively eroded by high flows

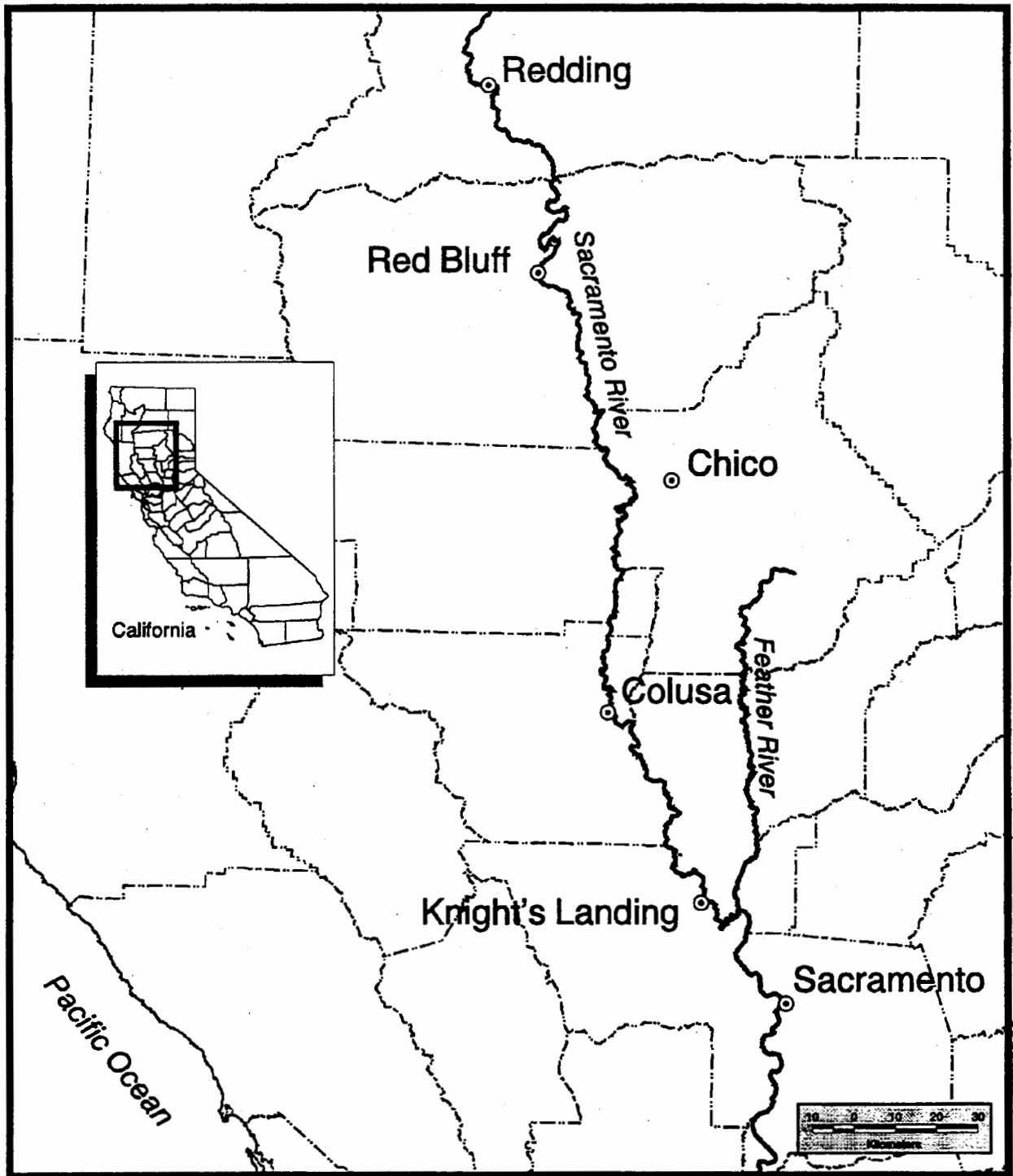


Fig. 1. Bank swallow population monitoring project, Sacramento River study area, 1986-1996.

during winter, provide essential habitat for nesting bank swallows during spring and summer annually.

METHODS

During 1986-87, intensive research was conducted on bank swallow populations and reproductive biology, and the methods employed in these earlier studies are reported in Garrison et al. (1987), Humphrey and Garrison (1987), and Laymon et al. (1988). During the monitoring period from 1988 to 1996, similar methods to locate, describe, and count burrows at active colonies were employed during 3-4 day surveys conducted in early June each year.

The methods for finding and counting active colonies were designed to reduce observer bias, ensure that relatively inexperienced observers, given adequate training, could gather useable data and allow repeatability. Observers consisted of personnel from CDFG and other State and Federal natural resource agencies. Inexperienced observers were trained by experienced observers and at least one experienced observer always participated in the surveys (Humphrey and Garrison 1987).

A jet boat was used to transport the monitoring crew of 3-4 observers on the Sacramento River during surveys. The travel direction was always from north to south, moving downstream with the river current. Colonies were located on the river and mapped using the most current edition of the U. S. Army Corps of Engineers Sacramento River Atlas. Colonies found with the previous year's surveys (beginning with the 1986 intensive study) were located each year, and any additional colonies were also recorded during the survey. When an active colony was encountered (as evidenced by birds flying in and out of burrows or other signs of activity), the boat was positioned 10-20 m from the site with the bow facing upstream and the motor's speed matching that of the current so that counting of burrows could proceed from a relatively stable platform. The boat was maneuvered slowly upstream until the counting was completed. Based on activity and completeness criteria that were developed by Humphrey and Garrison (1987), all burrows within the obviously active portion(s) of a colony were counted by 2 observers simultaneously using hand-held tally counters. Results were compared after each count to ensure that each observer's total was precise to within 10% of the companion observer's total for a particular colony. If the 10% figure was exceeded, the count was repeated until a less than 10% difference was achieved. A Trimble global positioning system (GPS) recorder was used during the 1996 survey to fix the location and linear extent of active colonies. In earlier years, however, colony locations were estimated and recorded on the Sacramento River Atlas.

Notes on habitat condition and other data were recorded at active and inactive colony sites. Photographs were taken to record certain characteristics or as a routine to describing the habitat. Each of the 3-4 reaches of the river surveyed required an entire day to complete and extended for about 30-50 River Miles.

Research at individual colonies was conducted in 1986 and succeeding years to yield information on reproduction, habitat characteristics, banding results, and bank swallow ecology. From these studies, a burrow occupancy figure of 45% was derived to estimate the number of breeding pairs from total burrow count recorded during monitoring.

RESULTS

In 1986, a total of 60 colonies with an estimated 28,894 burrows and a 56% burrow occupancy figure resulted in a population estimate of 16,149 pairs of bank swallows on the Sacramento River (Humphrey and Garrison 1987). Later studies and monitoring results have established a burrow occupancy estimate of 45% for an 11-year period, and the 1986 population was revised to an estimated 29,260 burrows in 72 colonies with about 13,170 pairs on the Sacramento River. (CDFG 1995; Table 1).

In 1987, Laymon et al. (1988) found 53 (later revised to be 66 colonies; CDFG 1995) colonies (48%) of California's total of 111 colonies on the Sacramento River. An additional 18 colonies (16%) were found on the Feather River which is a major tributary of the Sacramento River. Other concentration areas included Cache Creek (5 colonies), Klamath Basin, and Modoc County (14 colonies). Most historical records of bank swallow nesting colonies were from central and southern California where populations no longer exist. Only 4 colonies were found south of San Francisco Bay; the southernmost was near the Salinas River at King City, Monterey County. The Sacramento River population estimate (53 colonies; 25,329 burrows) and the Feather River population (18 colonies; 6,529 burrows) comprised about 64% of the colonies and 71% of the burrows in the California population in 1987 (Laymon et al. 1987).

Since these early studies, there has been a continual decline (about 9% each year) in the numbers of burrows (a convenient and readily obtainable index of population abundance) and the number and average size of individual colonies (Table 1). The 1996 survey indicated that the population continues at a low level relative to earlier years. The 1996 count was slightly larger than the 1995 count which was the lowest recorded population since the Department's 1986 baseline study (Table 1). By applying a factor to account for the proportion of burrows dug that are actually used for nest sites (a bur-

Table 1. Bank swallow population monitoring results summary by reach (River Mile (RM)) of the Sacramento River, 1986-1996.

Year	Data	RM 81-143	RM 144-168	RM169-199	RM 200-243	RM 243-292 ^a	RM 81-292
1986	No. colonies	13	15	15	23	6	72
	No. burrows	2480	6060	7530	11530	1660	29260
	Ave. bur./col.	190	400	500	500	280	410
	Breeding pairs	1120	2730	3390	5190	750	13170
1987	No. colonies	12	13	16	20	5	66
	No. burrows	3720	6600	5070	8540	1400	25330
	Ave. bur./col.	310	510	320	430	280	380
	Breeding pairs	1670	2970	2280	3840	560	11400
1988	No. colonies	9	18	28	16	5	76
	No. burrows	1870	7790	9570	6520	1290	27040
	Ave. bur./col.	210	430	340	400	260	360
	Breeding pairs	840	3510	4310	2930	580	12170
1989	No. colonies	6	14	21	16	5	62
	No. burrows	750	6580	6970	6520	1290	22110
	Ave. bur./col.	130	470	330	400	260	360
	Breeding pairs	340	2960	3140	2930	580	9950
1990	No. colonies	6	15	15	15	3	54
	No. burrows	980	7440	4850	6880	820	20970
	Ave. bur./col.	160	500	320	460	270	390
	Breeding pairs	440	3350	2180	3100	370	9440
1991	No. colonies	6	9	14	13	5	47
	No. burrows	1870	6110	3960	4300	1290	17530
	No. bur./col.	310	680	280	330	260	370
	Breeding pairs	840	2750	1780	1940	580	7890
1992	No. colonies	9	14	15	14	5	57
	No. burrows	1650	6840	4500	4050	1290	18330
	Ave. bur./col.	180	490	300	290	260	320
	Breeding pairs	740	3080	2030	1820	580	8250
1993	No. colonies	8	15	11	10	5	49
	No. burrows	1610	5230	1950	3820	1290	13900
	Ave. bur./col.	200	350	180	380	260	280
	Breeding pairs	720	2350	880	1720	580	6260
1994	No. colonies	6	11	10	10	5	42
	No. burrows	2470	4870	3400	4440	1290	16470
	Ave. bur./col.	410	440	340	440	260	390
	Breeding pairs	1110	2190	1530	2000	580	7410
1995	No. colonies	4	12	11	15	5	47
	No. burrows	540	2080	2510	4660	1290	11080
	Ave. bur./col.	140	170	230	310	260	240
	Breeding pairs	240	940	1130	2100	580	4990
1996	No. colonies	5	12	11	19	5	52
	No. burrows	700	2690	2490	5650	1290	12820
	Ave. bur./col.	140	120	230	300	260	250
	Breeding pairs	320	1210	1120	2540	580	5770

^a Data estimated in 1988-89 and 1991-96

row occupancy figure of about 45%), the estimated population of breeding pairs of bank swallows has declined from 13,170 pairs in 1986 to only 5,770 pairs in 1996. Consequently, the current population of nesting pairs on the Sacramento River is only 44% of that recorded 11 years ago. The average size of a colony has declined from 410 burrows in 1986 to about 250 in 1996, and the total number of colonies has declined from 72 in 1986 to 52 in 1996. The estimated population decline of bank swallows for the past 11 years (expressed as difference in total burrow counts between 1986 and 1996) has been about 56% (Table 1).

DISCUSSION

Decline of the population

The decline of the bank swallow population on the Sacramento River is not fully understood, but it appears likely that continued loss of colony sites from bank protection projects may not contribute to population stability or recovery. Possible causes of the decline may include the residual effects of decades of habitat loss beginning in 1960 when the Sacramento Bank Protection Project was first authorized by the U. S. Congress. Most work in the past 5 years, however, has occurred downstream of the major population center of bank swallows. The effects of the drought during the late 1980's and early 1990's may have also contributed to the decline. The recent wet period with its higher river flows and incompatible (with bank swallows) patterns of erosion may also contribute to habitat unsuitability and consequent lower breeding populations on the Sacramento River. Whatever the cause of the decline (including any natural factors), the bank swallow may be threatened with extirpation in the State if current trends continue into the foreseeable future.

Habitat Destruction and Disturbance

Since 1960, there has been an extensive loss of bank swallow nesting habitats due to erosion control and bank protection projects on the Sacramento river. We can only speculate about the magnitude of nesting population loss due to past projects that have been completed by State and Federal agencies since 1960. Any significant level of continued rip-rapping of stream bank in conjunction with flood and erosion control projects may represent the greatest human-caused threat to bank swallow populations and habitat on the Sacramento River.

Erosion is the natural process that creates bank swallow habitat and it is this process that has been curtailed by rip-rap projects in the past. According to documents available from the Corps (U.S. Army Corps of Engineers 1983) and the Department of Water Resources (Jones & Stokes Associates 1987), many of the existing

colony locations that we have documented may be destroyed, as will extensive areas of potential habitat. While it is understood that alternatives to traditional rip-rap are now being examined by the agencies, those measures may still result in reduced amounts of available habitat for bank swallows, a species that is totally dependent on natural erosion of stream banks to produce suitable nesting colony sites.

Garrison (1991) reported that bank protection work completed between 1986 and 1988 resulted in the loss of 9 known colony sites. Bank protection projects removed habitat at 5 colonies (4 completely and 1 partially) in 1986 and 1987. Habitat at an additional 2 colonies was eliminated in 1988 during construction of projects in the Butte Basin reach of the Sacramento River (RM 169-199).

In 1986, stream bank habitat at Woodson Bridge State Recreation Area, Butte County, had one of the largest colonies (approximately 1,350 pairs) ever documented in California (Humphrey and Garrison 1987). Construction of the palisades flow modification project occurred after the 1986 bank swallow nesting season. In 1987, only a third of the number of bank swallows returned to nest at the site. Two years later, the site was abandoned and has not been active since. Another large colony (approximately 1,050 pairs) was lost to rip-rap in 1988 and subsequently became the site of experimental mitigation habitat (discussed below).

It is possible that construction activities may also adversely impact swallow behavior and cause direct mortality during the nesting season when projects proceed in close proximity to active colonies. Construction activities with the greatest potential impact to bank swallow habitats have been planned for the reach of the Sacramento River that extends from RM 143 to RM 243 (U.S. Army Corps of Engineers 1983). This is coincidentally the region of greatest bank swallow abundance in the State. It is currently unknown whether or not the Corps and the State plan to continue bank protection in this area.

Natural Loss Factors

The bank swallow population has probably always had to contend with a certain degree of natural loss, sometimes quite devastating in extent. Predation of young and adult birds occurs. Predation of nestlings by gopher snakes appears to be a significant source of mortality at individual colonies. However, snake predation has been related to declines in habitat suitability at bank swallow colonies (Blem 1979). Reducing natural erosion on river banks through the use of "palisading" or other flow restriction devices could increase snake predation at colonies.

Another potentially serious threat exists from bank sloughing at Sacramento River colony sites. Although it appears to be a natural event, sloughing can result from high stream flows in summer caused by regulated water flows from Shasta Dam, and occasionally by recreational boaters whose wakes cause wave action that weakens banks and causes them to fall into the river. Depending on the timing of these events, significant loss of eggs, young, and some breeding adults may occur. Natural sloughing events do occur depending on the severity of winter storms and attendant erosion of stream bank. Since the bird is migratory and is absent from breeding areas in California from about September to March, it is not subject to any direct mortality caused by winter flooding. However, the bank swallow is adapted to cope with and exploit this natural erosion that modifies existing habitat and creates new habitat.

CONCLUSIONS

The Current Trend

If the current trend of habitat loss and population decline continues unchecked, the prospect for the long-term survival and eventual recovery of the bank swallow on the Sacramento River, and perhaps the remainder of the State, is poor. Because the bank swallow is listed as a State threatened species, the Corps, and their State sponsor for the bank protection project, the Reclamation Board, are required by the CESA to consult with CDFG when their proposed construction activities have the potential to cause adverse impacts to the species and its habitats. This protection afforded by the CESA has already greatly modified the way bank protection proceeds in the State. Since the listing of the bank swallow in 1989, no construction activities are allowed within 0.3 km of active bank swallow colonies. The exclusion zone is enforced during 1 April to 1 August to avoid the nesting season of the bank swallow and has been a condition included in several State rendered biological opinions specifically to prevent take of the species. This exclusion zone has prevented the direct mortality of nestlings and eggs during the nesting season, an impact that apparently was widespread prior to the protection afforded by the CESA.

While the direct take of the species issue has been resolved satisfactorily through avoidance measures, the take of essential habitats resulting from bank protection activities has yet to be adequately mitigated. Since bank protection and other kinds of erosion control projects have the potential to negatively affect bank swallow habitat and populations and prevent recovery from taking place, the need to develop effective habitat conservation and mitigation measures is of paramount importance if the species is to survive in California.

Prospects for Recovery

Other than the take avoidance measures already described and the delay and modification of certain work sites on a case by case basis through CESA consultation, there are currently no specific habitat conservation or management actions, either private, State, Federal, or local being implemented to protect bank swallows and their habitat on the Sacramento River. However, much of what may need to be implemented is contained as recommended actions in the State's Bank Swallow Recovery Plan (CDFG 1993).

It may be necessary to preserve, through conservation easement, wild and scenic river designation, or purchase in fee title all existing and potential bank swallow habitat on the Sacramento River. Some of the current efforts to preserve habitat through the Sacramento River National Wildlife Refuge, certain State lands, and the activities of Riparian Habitat Subcommittee of the Upper Sacramento River Advisory Council may eventually result in significant habitat preservation that would help improve the status of the bank swallow.

In addition, a working agreement has been signed by several State and Federal agencies and conservation organizations for the Riparian Habitat Joint Venture (RHJV) of the California Chapter of Partners in Flight. The Corps and the Reclamation Board, although not part of the RHJV, are represented on the Riparian Habitat Subcommittee of the Upper Sacramento River Advisory Council.

Although some attempts were made to provide substitute nesting habitat at a few bank protection work sites, these were largely a failure due to the lack of maintenance by responsible agencies. This led to the eventual abandonment of these sites by bank swallows. These largely experimental attempts to replace lost habitat at a site where natural colonies were destroyed by rip-rap were evaluated for their feasibility. Garrison (1991) concluded that although early results were encouraging (birds appeared to breed normally at the experimental banks), the inherent problems of long-term site maintenance costs and the risk of placing a large segment of the population in a totally artificial system would be difficult to overcome and the use of artificial banks could not play a major role in the recovery of the species. Therefore, the technique does not figure prominently in the CDFG recovery plan. Other measures have been proposed to curtail erosion that do not employ traditional rip-rap; however, these too have unacceptable impacts in that they prevent the creation and natural maintenance of critical habitat features, namely eroding river banks (CDFG 1993).

While relatively little of the management and acquisition actions contained in the recovery plan have been implemented, there has been some progress in ongoing coordination efforts between the concerned agencies. The CFDG employs staff to monitor bank protection projects that may negatively impact bank swallow habitat. Several CESA consultations have rendered CFDG biological opinions that protect bank swallows from take. There has been no construction-related take of the species since it was listed in 1989. In addition, early coordination prior to listing (1985-89) also prevented mortality of eggs and young at active sites. Some important habitat has been acquired by both the State and the Federal Wildlife Refuge system. As an outcome of the passage of Senate bill (SB) 1086, several representatives of agencies, conservation organizations, and the public are involved in efforts to preserve riparian areas. While these and other positive programs regarding the preservation of riparian habitat are encouraging, many specific recovery actions need to be implemented before the bank swallow population, particularly on the Sacramento River, can be recovered.

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