POPULATION TRENDS AND MANAGEMENT OF THE BANK SWALLOW (*RIPARIA RIPARIA*) ON THE SACRAMENTO RIVER, CALIFORNIA[1]

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Abstract: Annual monitoring of Bank Swallows (Riparia riparia) *along the Sacramento River, California has been conducted since 1986 to determine population trends, evaluate impacts from bank protection and flood control projects, and implement and monitor mitigation efforts. The population of Bank Swallows in a 50-mile river reach remained static over 3 breeding seasons from 1986 to 1988 despite ongoing bank protection projects. The proportion of burrows occupied by breeding swallows and the mean number of young/nest with young in a nesting colony was not significantly different between 1986 and 1988. Six experimental mitigation sites constructed in 1988 were successfully used by breeding Bank Swallows.*

Studies of the Bank Swallow in California began in 1986 after Remsen (1978) reported a population decline which he attributed, in part, to state and federal bank protection and flood control projects. On the Sacramento River, these projects occur on eroding riverbanks, and they involve removal of riparian vegetation, reshaping vertical riverbanks, and placing rock revetment (riprap) on the bank to prevent erosion.

Bank Swallows require vertical banks in silty, loamy, and sandy soils close to water for nesting (Freer 1977; Garrison and others 1987; Spencer 1962). Actively eroding riverbanks provide these nesting requirements, therefore, riprap projects and Bank Swallow nesting habitat requirements are incompatible. Five known nesting sites on the Sacramento River have been destroyed by riprap projects since population monitoring began in 1986. Garrison and others (1987) and Humphrey and Garrison (1987) found that a significant amount of Bank Swallow nesting habitat on the Sacramento River could be lost with riprap construction. Over 50 percent of California's Bank Swallow population occurs on a 210-mile stretch of the Sacramento River (Laymon and others 1988).

This paper will report (1) trends in the Bank Swallow population on the Sacramento River from 1986 to 1988, (2) impacts of riprap projects to the population, (3) preliminary results from experimental mitigation efforts, and (4) management activities. This paper utilizes data from earlier papers (Garrison and others 1987; Humphrey and Garrison 1987; Laymon and others 1988) and additional data collected in 1988.

Study Area and Methods

Our study was conducted on the Sacramento River between Chico Landing, Butte County, River Mile (RM) 195, and Colusa, Colusa County, RM 144. This river reach is lined by riparian forests typical of the Central Valley of California (Warner 1984) and agricultural lands. Dominant riparian trees are cottonwood (*Populus fremontii*), red willow (*Salix laevigata*), black willow (*S. lasiandra*), box elder (*Ater negundo*), and valley oak (*Quercus lobata*). Agricultural lands include orchards and row crops. The Sacramento River is an alluvial river with natural levees and a meandering channel, however, man has greatly altered the natural fluvial processes occurring in the river (Scott and Marquiss 1984).

Surveys were conducted by boat from early April to early June from 1986 to 1988. Colony locations were plotted on 1:24,000 scale black-and-white aerial photographs and described to the nearest 0.1 RM. The study area was divided into 4 river reaches (RM 144-155, RM 156-170, RM 171-185, RM 186-195) to assess colony dynamics. At all 43 colonies in 1988, 29 of 30 colonies in 1987, and 21 of 31 colonies in 1986, the number of burrows was counted with a tally counter. Visual estimates were made at the remaining colonies in 1987 (1 colony) and 1986 (10 colonies) (see below). Burrow counts from each colony were rounded to the nearest 10 burrows. Burrows counted had dark entrances (> 2 cm deep) when viewed from a distance of 5-25 meters. We counted all burrows in active sections of banks and did not count old burrows from inactive sections. Bank Swallows flying into burrows were used to determine activity, and we observed colonies for 15-60 minutes to assess whether or not a colony or section of colony was active.

There are several considerations when quantifying Bank Swallow populations using burrow counts. First, it is sometimes difficult to distinguish freshly dug burrows of the current nesting season from those remaining

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from previous years which may not be used for nesting. However, we observed swallows nesting in old burrows, a practice also reported by others (Hickman 1979; Peterson 1955; Svensson 1986). Some old burrows were clearly unusable because the habitat was unsuitable due to vegetation coverage or lack of a vertical bank. In addition, inactive burrows from previous years were often filled with spider webs, vegetation, or collapsed soil. Also, portions of the bank with old burrows suitable for nesting were inactive for unknown reasons.

Not all burrows in a colony are used for nesting (Freer 1977; Garrison and others 1987; Hickman 1979; MacBriar and Stevenson 1976; Svensson 1986). However, burrows counts are an obvious measure of colony size and are data that are inexpensive to collect and repeatable. In addition, each burrow is dug by at least one swallow, and burrow digging is part of their breeding behavior (Beyer 1938; Peterson 1955). In this study, burrow counts are supported by data on the proportion of burrows occupied in a colony by nesting birds.

Burrow number was estimated at 1 of 30 colonies (3 percent) in 1987 and 10 of 31 colonies (32 percent) in 1986. Garrison and others (1987) reported that these estimates in 1986 underestimated the actual number of burrows in a colony by an average of 6 percent. Underestimates were due to inaccuracy in the estimates and burrow additions and/or losses after the estimates were made. Timing of burrow counts, particularly in the early spring when burrows are dug, results in variability in burrow numbers (Jones 1987). However, both complete counts and estimates change with burrow additions and losses. For this study, complete counts and estimates were combined in 1987 and 1986 to estimate population abundance.

The proportion of burrows occupied by nesting birds was estimated at 15 randomly selected colonies of 31 colonies in 1986. Equivalent data were collected at 11 of 43 colonies in 1988. In 1988, 6 of the 11 colonies were in manmade sites constructed as experiments to test the feasibility of mitigation, and the remaining 5 colonies were in natural sites that were randomly selected. Percent occupancy did not differ (Mann-Whitney Test, $U = 8.0$, $P = 0.247$) between manmade and natural sites in 1988 so data were combined.

Within a colony, a sample of burrows (n = 16-100) was checked using a flashlight and an angled dental mirror attached to an extendable automobile radio antenna. Burrows checked were in groups of 5-15 spaced approximately 2 m apart across the face of the colony, and these burrows generally were in accessible sections of the nesting bank. Burrows with eggs, young, a nest, or an adult in incubating or brooding posture were considered occupied, and burrows of unknown status were excluded. The number of young in a nest were counted and the mean/nest with young was calculated as a measure of colony productivity.

Experimental mitigation attempts began in September 1987 with the construction of 1 site above a riprapped bank using soil from the colony which was destroyed when the bank was riprapped. A vertical face 1.3-1.7 meters tall was cut there in March 1988. Additionally, 5 vertical banks were constructed in March 1988 on existing riverbanks which were unsuitable for swallow nesting because bank faces were not vertical and/or covered with vegetation. These 6 sites were monitored from March to June 1988, and data collected were equivalent to that at natural sites. Garrison (1988) provides more details on the experimental mitigation sites.

A Kruskal-Wallis test was used to determine differences in populations in the 3 breeding seasons from 1986 to 1988. The Mann-Whitney 2-sample test was used to determine differences in percent occupancy and mean number of young/nest with young between 1986 and 1988 and between natural colonies and colonies at experimental mitigation sites in 1988. Percent occupancy and mean number of young/nest with young were calculated from 4 and 3 colonies at the same locations in 1986 and 1988, respectively. A Chi-square test was used to assess differences in patterns of colony abundance among the 4 identified river reaches and colony site dynamics (Zar 1974). Significance was set at $P < 0.05$.

Results and Discussion

Population Trends

The Bank Swallow population was not significantly different during the 3 breeding seasons from 1986 to 1988 (Kruskal-Wallis Test, $H = 2.20$, df = 2, $P = 0.333$) (table 1, fig. 1). The number of colonies did not differ significantly (Chi-square Test, $x2 = 1.38$, df = 6, $P < 0.95$) between years from 1986 to 1988 within 4 river

Table 1 -Total number of burrows and colonies, mean and standard error (SE) of burrows per colony, and percent change of Bank Swallow populations on the Sacramento River, California, 1986-88

	1986	1987	Pct. Change 1986 to 1987	1988	Pct Change 1987 to 1988
Total Burrows	13,780	12,090	-12	16,710	38
Colonies	31	30	-3	43	43
Mean + SE	440 ± 80	400 ± 70	-9	390 ± 80	-3

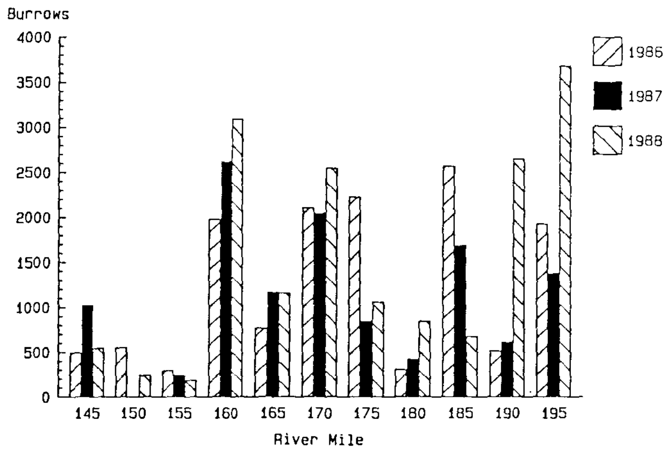

Figure 1—Number of burrows at Bank Swallow colonies by 5-river-mile sections on the Sacramento River, California, 1986-88.

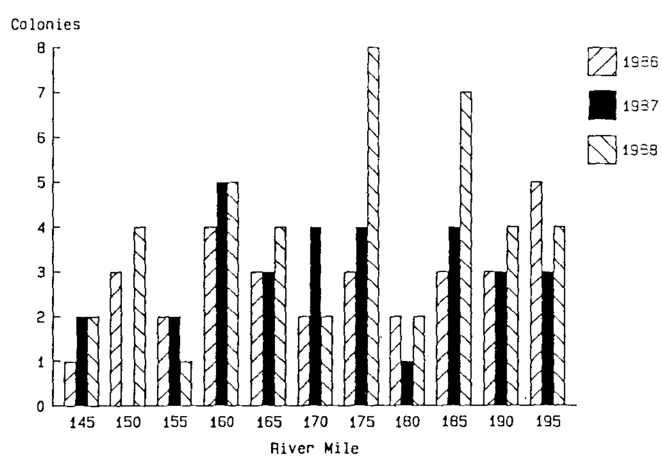

Figure 2—Number of Bank Swallow colonies by 5-river-mile sections on the Sacramento River, California, 1986-88.

Table 2 - Use patterns of Bank Swallow colonies on the Sacramento River, California, 1986-88

	Years	
Use Pattern[1]	1986-87	1987-88
Active site used the previous year	22 (56)[2]	21 (40)
Active site not used the previous year	8 (21)	22 (42)
Inactive site used the previous year	9 (23)	9 (17)
Total[3]	39 (100)	52 (99)

[1] Pattern based on comparing use at a colony site in one year (e.g., 1987) with use the previous year (e.g., 1986).

[2]Number in parentheses are percentages.

[3]Total different than number p (colonies located in a given year because of addition of inactive sites.

reaches in the study area (table 1, fig. 2). Colony site dynamics was assessed by categorizing colonies from the 3 study years into 1 of 3 groups based on site use over a 2-year period. For example, colony site dynamics in 1986 and 1987 was based on activity for those two years. A consistent pattern of colony site dynamics existed between the periods 1986 to 1987 and 1987 to 1988 (Chi-square Test, $X^2 = 4.87$, df = 2, $P < 0.10$) (table 2).

The abundance and distribution of the Bank Swallow population within the study area remained relatively uniform over the 3-year period from 1986 to 1988. However, the size of individual colonies fluctuated, several sites were abandoned, several abandoned sites were later reoccupied, and new sites were established. The fact that the population remained relatively constant despite considerable site dynamics indicates that Bank Swallows are adapted to dynamic environments such as the Sacramento River where the location of suitable nesting sites may change periodically.

Proportions of colony sites used two successive years, abandoned following an active year, or used following an inactive year were statistically equal for the period 1986 to 1987 and 1987 to 1988. Despite the lack of statistical significance, twice as many colony sites in 1987 to 1988 (42 percent) than 1986 to 1987 (21 percent) were active following an inactive season.

Bank Swallow habitat is greatly influenced by high flows and erosion which create freshly exposed vertical riverbanks. This occurred most extensively in 1986 along the Sacramento River. In contrast, 1987 and 1988 were dry years characterized by relatively low river flows and reduced erosion. Suitability of nesting habitat was reduced at many previously occupied sites because riverbanks sloughed.

Although not statistically significant, the data suggest Bank Swallows occupy a greater proportion of nesting sites without previous use during dry years than wet years. In dry years, suitable habitat may be more widely distributed in smaller size habitat patches because of localized sloughing. The greater number of colonies and smaller mean colony size in 1988 compared to 1987 and 1986 provides supporting evidence. Additional data from other wet years are needed to fully answer this question.

Between 1986 and 1988, percent occupancy (Mann-Whitney Test, U = 78.5, P = 0.813) and the mean number of young/nest with young (Mann-Whitney Test, U = 17.5, P = 0.062) were equal. Therefore, colony occupancy by breeding birds and their productivity was the same in a wet year (1986) and a dry year (1988). In fact, percent occupancy was slightly greater in 1988 when some burrows remained from previous years:

Variable (Mean ± SE):	1986	1988
Percent occupancy	46 ± 5 (n=15 colonies) Range = 6-83	47 ± 4 (n=11 colonies) Range = 30-64
Number of young/ nest with young	2.7 ± 0.2 (n=9 colonies) Range = 2.1-3.	3.2 ± 0.2 (n=8 colonies) Range = 2.5-3.9

Impact Assessment

Since 1986, 5 colony sites within the study area have been riprapped. Because of the relatively constant population abundance and uniform distribution, it appears that there were not any adverse impacts from 1986 to 1988. Any adverse impacts may have been hidden by the ability of the Bank Swallow to adjust to changes in the abundance and distribution of suitable nesting sites. Several factors provide supporting evidence.

First, in 1988, Bank Swallows occupied 2 new sites just downstream from 2 sites riprapped in 1987. Second, all 6 mitigation sites constructed in 1988 were occupied. Third, the 5 colony sites impacted by riprap were relatively small colonies (< 410 burrows). Adverse impacts may be more likely to occur when large colonies (> 1000 burrows) are riprapped. In late 1988, another colony at RM 190.5 Left (2330 burrows) was riprapped, and population monitoring in 1989 may help answer this question.

Lastly, habitat necessary to maintain a uniform population over the 3-year study period may still be present. The number of nesting colonies increased from 31 in 1986 to 43 in 1988 indicating that habitat was available for a relatively constant population. However, future riprap projects will continue to eliminate available habitat. In turn, this could reduce the amount of available nesting habitat which would limit the ability of Bank Swallows to respond to environmental perturbations by establishing new colonies. We lack data on the abundance and distribution of suitable nesting habitat. However, our observations suggested that the majority of suitable nesting sites were occupied.

Preliminary Results from Experimental Mitigation

All 6 experimental sites were occupied by breeding Bank Swallows in 1988 (total = 1,150 burrows, mean ± SE = 190 ± 43, Range = 70-340). Percent occupancy was not significantly different (Mann-Whitney Test, U = 8.0, P = 0.247) between experimental sites (mean ± SE = 43 ± 6, n = 6 colonies, Range = 30-63) and natural colony sites (mean ± SE = 53 ± 4, n = 5 colonies, Range = 44-64). In addition, the mean number of young/nest with young was not significantly different (Mann-Whitney Test, U = 7.0, P = 1.000) between the experimental sites (mean ± SE = 3.1 ± 0.2, n = 5 colonies, Range = 2.5-3.9) and natural colony sites (mean ± SE = 3.2 ± 0.2, n = 3 colonies, Range = 3.0-3.6). Therefore, the experimental mitigation sites apparently were equivalent to natural colony sites in occupancy and productivity by providing the proper habitat conditions.

The 1,150 burrows at the 6 experimental sites approximately double the 690 burrows (most recent counts) lost at the 5 riprapped colonies. However, because of the ephemeral nature of Bank Swallow nesting colonies, we do not feel that simply replacing losses of burrows and individual colony sites is mitigation. Successful mitigation includes the maintenance of (1) population abundance and distribution along the river, (2) productivity and occupancy at natural and manmade sites, and (3) abundance and distribution of available habitat. Data from 1988 are the first of a 3-year monitoring program, and additional experimental sites will be constructed in 1988. However, at least the mitigation techniques tested thus far appear feasible.

There are several critical factors, however, influencing the ultimate success of the mitigation techniques tested to date. Many potential mitigation sites are on private lands requiring permission for construction and monitoring. In 1988, private landowners granted permission at 6 of 8 (75 percent) proposed sites. However, 9 of the initial 17 (53 percent) recommended sites were eliminated because of access and safety concerns, high costs, or habitat suitability questions, and the landowner was never contacted.

Also, 4 of the initial 13 (31 percent) sites recommended for habitat improvement (i.e., cutting a vertical face on existing riverbanks) were subsequently occupied in 1988 by nesting Bank Swallows without any habitat improvement. This result indicates that some of the recommended and constructed sites may not have provided any mitigation value because the birds could have nested there anyway. In addition, maintenance and monitoring commitments are necessary for the life of the project if mitigation is to succeed in compensating for habitat losses. Lastly, riprap projects also eliminate potential mitigation sites on existing riverbanks.

Management Activities and Recommendations

Bank Swallows have received considerable interest by agencies, environmental groups, and the public since our studies began in 1986. Population data have been gathered from 3 successive breeding seasons, the species is a candidate for listing as a threatened species in California, experimental mitigation has been implemented with a 3-year monitoring program, and concerned state and federal agencies are cooperating. Despite these efforts, the Bank Swallow's future in California is far from secure. Riprap projects are continuing on the Sacramento River where the species is most abundant, and habitat is being permanently lost each year. We are unsure whether mitigation efforts can fully offset losses because many factors beyond our control affect the success of mitigation.

Annual monitoring should continue on the Sacramento River and include the entire population on the river, and a management plan should be developed to ensure the species' long-term viability. Establishing habitat preserves where Bank Swallow habitat as well as other riparian values are protected may ultimately be the most effective way of managing and preserving the species. Experimental mitigation efforts must be continued, and additional research is needed on habitat requirements and site tenacity.

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