# Overview of Cosumnes Riparian Bird Study and Recommendations for Monitoring and Management

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**Study Intent and Background**

Riparian habitat in California is one of the most productive and valuable habitats for all forms of wildlife. Yet this is also one of the most threatened habitats, with only about 5% of the state's original riparian habitat remaining. In addition to habitat loss, California's remaining riparian and floodplain ecosystems have been greatly altered and impaired since the mid-19$^{th}$ century. Historically, winter and springtime flooding provided for extensive flooded plains that were used by native fishes. Such flooding is key to the maintenance of riparian forests, once the predominant floodplain vegetation in the Sacramento Valley. Currently on most rivers, however, the natural hydrologic regime has been altered by dams and levees that alter the timing and magnitude of flows. Changes in hydrological regime and loss of habitat have had severe consequences for birds that depend on riparian habitat.

The Cosumnes River Preserve and adjoining habitat provide an opportunity to study the ecological processes necessary to restore and maintain riparian habitat through semi-passive means: specifically, levee breaching and levee setbacks that will allow natural processes to proceed. Our study focuses on evaluating the condition of the ecosystem, reflected in both recently restored habitat (through semi-passive, natural processes and through planting) and in the remaining, remnant riparian forest and scrub, using birds as a study system. Our objectives with regard to bird studies are four-fold: 1) to evaluate current conditions of bird communities and determine whether the current habitat (remnant and restored) is able to support stable or growing populations of riparian birds, 2) to gain insight into ecological processes (biotic and abiotic) that will maintain stable or growing populations as well as a diverse bird community, 3) to develop metrics of restoration success that can inform management practice, and 4) to provide the foundation for a long-term monitoring program for riparian-dependent birds and wildlife.

In 1995, in cooperation with The Nature Conservancy (TNC), PRBO began evaluating and monitoring the riparian bird communities within the Cosumnes River Preserve. PRBO implemented a multi-tiered integrated monitoring program following nationally standardized protocols (Ralph et al. 1993). To assess the condition of the songbird community we collected information on habitat usage, species diversity and demographic parameters (e.g., reproductive

success, Howell et al. 2006). Eleven years of data compilation on bird populations have been completed as of 2005.

In 2002, PRBO began to work with partners at UC Davis and UC Berkeley in the CALFED-funded study, *The influence of flood regimes, vegetative and geomorphic structures on the links between aquatic and terrestrial systems: Applications to CALFED restoration and watershed monitoring strategies.* With funding from the California Bay-Delta Authority, PRBO studied riparian bird populations during 2002-2005, with the aim of evaluating conditions of bird populations, improving our ability to evaluate restoration success, and, specifically elucidating the linkages between the terrestrial bird species and the aquatic ecosystem, which is characterized by intermittent flooding during winter and spring.

**Operational Hypotheses and Objectives**

In this study, we evaluate the following general hypotheses:

- Bird population and community characteristics vary in space, at least partly due to restoration state (as reflected in age or type of restoration).
- Bird population characteristics vary in time (over the duration of the 11-year study), partly due to hydrological conditions varying over time, but also due to other factors, including climate and weather variables.
- Observed population parameters will reflect an interaction of space and time mediated by restoration state.

We also evaluate several more specific hypotheses:

- Remnant riparian habitat is not of sufficient quality (due to habitat degradation, habitat fragmentation, incursion of non-native flora and fauna, and other influences) in order to maintain stable populations of riparian birds.
- Restored habitat provides habitat that improves the condition of riparian bird populations, as reflected in population trends.
- Population trends and demographic rates will differ among sites due to restoration state.
- Time since restoration was initiated influences characteristics of bird populations and/or the avian community.

- Populations of riparian birds respond, directly or indirectly, to hydrological regimes (such as flooding) and/or weather variables (such as rainfall).
- The response to hydrological state reflects the food-web mediated linkage between aquatic and terrestrial ecosystems.

To evaluate these hypotheses, we analyzed abundance data at 12 study sites over an 11-year period for 22 bird species that use riparian habitat for breeding and analyzed reproductive success for one species, the Song Sparrow, at six study sites over the same 11-year period.

## Methods

### Point Count Surveys

Point counts are a nationally standardized, cost-effective method for estimating avian species diversity, species richness, relative abundance and, over time, population trends (Ralph et al. 1993, Nur et al. 1999). Five-minute, variable distance point counts were used in which the distance from the observer to each individual detected (including raptors and swallows foraging over the plot) was estimated from a fixed point. Surveys began at local sunrise and were completed within four hours, as long as weather conditions were favorable (no rain or high winds). All breeding bird surveys were conducted April through June in all years which corresponds to the songbird breeding season. At least two surveys were conducted at each point count station.

### Nest searching and monitoring

Nest monitoring provides site- and habitat-specific information on avian productivity, its components and also allows one to estimate rates of cowbird parasitism (Martin and Geupel 1993, Nur et al. 1999). Nest finding and monitoring followed guidelines outlined in Martin and Geupel (1993) and utilized techniques that minimize disturbance to the adults and nest site. All nests found were checked at least once every four days and the nest contents (e.g., eggs or young) and the final outcome (fledged or failed) were recorded. Information on clutch size and number of fledged young as well as presumptive cause of failure was recorded. All species' nests encountered were monitored. Here we analyze only Song Sparrows, the species with the largest sample size and an excellent study species, which has been extensively studied in California and western North America. All data recorded in the field were entered into an electronic database (www.prbo.org/tools).

### Analysis of Point Count Data

For each species, we analyzed the number of detections per point-count station in each year, summed over two visits. Statistical analysis was conducted with negative binomial regression using the program STATA 8 (Stata Corp. Release 8). We also analyzed two community-wide, multi-species metrics: total individuals detected and bird species diversity. To facilitate comparison with bird species richness, bird species diversity was analyzed using a

transformation of the commonly used Shannon index (the latter symbolized H′ [Nur et al. 1999]). The transformed index used here is $N_1$ (measured in terms of species instead of bits of information), where $N_1 = e^{H'}$ (Nur et al. 1999). To determine whether trends differed between restored and mature habitat we tested for the significance of an interaction in trend. To determine non-linearity of trend we tested for the significance of non-linear terms with respect to year.

Analysis of Nest survival

We used an information-theoretic approach to evaluate relationships between daily nest survival and the covariates of interest. These covariates reflected age of the nesting attempt (i.e., what part of the nesting cycle), site, restoration status, winter flooding, spring flooding (early and late in the breeding season), winter rain, rain during the late breeding season, Southern Oscillation Index, and nest height. Nest survival analyses were calculated with the logistic exposure method, a type of discrete survival analysis (Shaffer 2004). We took a hierarchical model selection approach in our analyses and began by examining five sets of hypotheses pertaining to different influences on nest survival as well as considering a constant survival model (null). For each of the five hypothesis sets we determined the most important variable for that hypothesis using model selection.

We calculated Akaike's information criterion (AIC) corrected for small sample size (AICc) as well as Akaike weights ($w_i$) to identify the best of the candidate models. We then advanced the top model from each of the hypotheses into the final model. To arrive at a final, overall model we evaluated all combinations and subsets of the variables that were advanced into the candidate model set and used model averaging to determine coefficients and standard errors for the top model. We examined whether the effect of variables depended on restoration status by examining interactions between the variable in question (e.g., winter flooding) and restoration status (mature site, restored through natural processes, or restored through planting).

**Key Findings**

Species diversity and abundance of individual species differed among sites. A large part of this variation was due to variation in age of the riparian habitat, comparing restoration sites of various ages (1 to 22 years since restoration) with mature riparian habitat. Bird species diversity and total number of individuals increased with age of riparian habitat, with about a two-fold difference for both parameters comparing young restoration sites and mature riparian sites. Differences in these metrics were greater among habitat types than they were among sites within a habitat type. Among the 22 species examined, trends in abundance for the entire study area were as likely to be positive as negative. However, trends in abundance for individual species in many cases differed when comparing mature riparian sites with restored riparian sites. Trends for the 22 species in mature riparian habitat were as likely to be decreasing as increasing; six species (Ash-throated Flycatcher, Bewick's Wren, House Wren, Oak Titmouse, Bullock's Oriole, Mourning Dove) demonstrated statistically significant declines, many of them cavity-nesting species. Mechanisms responsible for the decline remain to be identified, though our studies of nesting songbirds suggest that high nest predation rates may be responsible. **Preservation of mature, remnant riparian habitat does not appear to be by itself sufficient to maintain healthy populations of many species.** Instead, restoration of additional habitat will be required, at a minimum.

In restored habitat, population trends for the 22 species were generally positive. These species often demonstrated species-specific responses consistent with known habitat preferences. For example, for the Spotted Towhee, a ground-nesting species associated with leaf litter from trees, individuals were not commonly observed until year 9 following restoration. In contrast, Common Yellowthroats, a species associated with herbaceous and shrubby plants, were observed to first increase and then decrease in abundance as restoration habitat aged.

Reproductive success of Song Sparrows also differed among sites, with the primary difference reflecting type of restoration: none (i.e., mature riparian habitat), semi-passive (process-based), or active (horticultural). Reproductive success of this species varied markedly among years. El Niño years tended to have lower reproductive success and La Niña years tended to have higher reproductive success. El Niño years are characterized by greater rainfall during the early spring (early breeding season) and this may be the proximal factor responsible

for the observed pattern. A second factor explaining between year variation in Song Sparrow reproductive success is winter flooding: the greater the flooding, the greater the survival of Song Sparrow clutches during the following spring. Note that ENSO events (reflecting El Niño and La Niña years) are not correlated with winter flooding. The mechanisms responsible for this correlation may involve changes in vegetation leading to greater or less concealment, changes in insect abundance, and/or changes in predator activity or predator populations associated with ENSO events or flooding.

Tree Swallows also demonstrated a positive response to winter flooding: their breeding season abundance increased as a function of the extent of flooding in the immediately preceding winter. Tree Swallows feed on flying insects, which often have an aquatic life stage, and insect abundance may have been enhanced in years of extensive winter flooding. In contrast, terrestrial bird species demonstrated a negative response to winter flooding in terms of abundance, which may reflect changes in vegetation associated with flooding. Thus, Song Sparrows evidenced two divergent responses to winter flooding: reproductive success was greater in the subsequent spring with greater winter flooding but the abundance of adults was lower during the same time period. Enhanced reproductive success would imply that populations would be greater in the following spring as well (since Song Sparrows first breed during their first year), 15 months after winter flooding, and this pattern was indeed observed.

Finally, responses often differed depending on restoration state of the study plot. For example, winter flooding influenced reproductive success of Song Sparrows at all sites, but the effect was strongest at restoration sites. Similarly, the depression in abundance of adult Song Sparrows in relation to flooding the preceding winter was only observed at restoration sites.

This study demonstrates the critical role restored riparian habitat plays in maintaining or augmenting populations of a broad suite of landbird species. Linkages between population processes of riparian songbirds and the adjacent floodplain were demonstrated, suggesting several mechanisms at play and not just a single one.

## Recommendations for Monitoring

Rationale for Monitoring

Two types of monitoring are needed: 1) monitoring of the condition of target populations, in this case birds dependent on riparian habitat, which includes measures of abundance as well as primary demographic parameters such as reproductive success and 2) monitoring the response to restoration and other management activities. The second type of monitoring is key to successful adaptive management. One of its goals is to allow for evaluation of successful ecosystem restoration. Many restoration projects have taken success to mean approximating historic conditions. However, this is not often feasible or desirable with today's changing landscape, altered hydrologic regimes and introduced predator community. What may have been good for birds in the past may not represent ideal conditions in the present. Thus, it is important to monitor the effects of restoration and other management actions on bird populations and underlying demographic processes. For many projects the goal of restoration is to create habitat to benefit wildlife and yet many of these projects do not adequately measure the wildlife response to restoration. Those projects that do measure wildlife response often rely on community level metrics such as species richness, diversity or total number of individuals detected. Different species do not respond similarly to environmental influences such that interpretation of community level responses requires information on individual species. Therefore community level metrics can be ineffective or worse, misleading when used as monitoring tools. Instead, we recommend collecting data on all bird species and analyzing a subset of those species with sufficient sample sizes that best represent the bird community as a whole. This is in contrast to relying on only a few, or worse, a single listed species to evaluate and guide restoration actions. In many cases, these single species are rare making it difficult or impossible to collect sufficient data upon which to base management recommendations.

The following recommendations are designed to ensure that a monitoring program is implemented that can evaluate the effectiveness of restoration, including process-based restoration. Our recommendations for monitoring are also designed to help answer specific questions about what factors influence songbird abundance, distribution, productivity and

survival (e.g., what is the effect of winter flooding on the productivity of a ground-nesting songbird)?

**Selecting study species for analysis**

Criteria for selecting study species for analysis should include 1) sufficient sample size for statistical analysis, 2) dependent on riparian habitat for key life history stages, 3) of particular management concern (e.g., listed, special status, declining population size and 4) collectively spanning a range of life history traits. The key to our approach is to study demographic parameters that reflect "health" of populations of individual species (each with their own ecological characteristics) and not simply abundance or density (Temple and Wiens 1989; Baillie 1990). These parameters include population trend over time as well as components of reproductive success, and ultimately, survival of adults and young.

**Cosumnes study species:**

We recommend analysis of species richness and species diversity for the entire community of riparian-associated birds during the breeding season (Nur et al. 1999). We recommend analysis of abundance and distribution during the breeding season for 22 riparian-associated species, consistent with criteria outlined above ("Selecting study species").

Table 1. Recommended study species for Cosumnes River Preserve for point count data (PC) and nest monitoring data (NM).

| Species | Method | Species | Method |
|---|---|---|---|
| American Goldfinch | PC | House Wren | PC |
| Ash-throated Flycatcher | PC, NM | Mourning Dove | PC |
| Bewick's Wren | PC | Nuttall's Woodpecker | PC |
| Brown-headed Cowbird | PC | Oak Titmouse | PC |
| Black-headed Grosbeak | PC, NM | Red-winged Blackbird | PC |
| Blue Grosbeak | PC, NM | Song Sparrow | PC, NM |
| Bullock's Oriole | PC | Spotted Towhee | PC, NM |
| Bushtit | PC | Tree Swallow | PC, NM |
| Common Yellowthroat | PC, NM | White-breasted Nuthatch | PC |
| Downy Woodpecker | PC | Western Scrub-Jay | PC |
| House Finch | PC | Wrentit | PC |

We recommend analysis of components of reproductive success for seven riparian-associated songbird species (Song Sparrow, Black-headed Grosbeak, Spotted Towhee, Common

Yellowthroat, Tree Swallow, Ash-throated Flycatcher and Blue Grosbeak). Nests for these species have been found and monitored in sufficient numbers to allow statistical analysis. Each of these species has been well studied in the Central Valley.

**Study site selection and monitoring chronology**

The unregulated flows of the Cosumnes River are characterized by frequent seasonal inundation and are highly variable regarding the extent, duration and timing of inundation. Investigating the relationship between flooding and various avian parameters requires long-term data. As with any long-term project, monitoring resources must be used efficiently and sites must be prioritized to ensure continuity of long-term data collection. High priority sites should meet one or more of the following criteria: 1) monitoring effort maintained throughout project lifespan, 2) of particular interest to conservation practitioners (e.g., restoration sites), and 3) overlap of methods on sites (e.g., point counts and nest monitoring). In addition to sites within the Cosumnes River Preserve, we highly recommend surveying sites in nearby drainages with regulated flows to serve as a comparison. PRBO study sites along the Mokelumne River surveyed from 2004 through 2006 would make ideal comparison sites.

The recommended number of years to continue monitoring, whether annually or less frequently, depends on the research objectives of the project (Nur et al. 1999). To study the effects of climate and hydrology on the avian community we recommend annual monitoring over the long term (30 to 50+ years). Note that the Pacific Decadal Oscillation has a period of that magnitude. For specifically evaluating restoration, we recommend annual monitoring for the first 15 years. Spotted Towhee abundance at Cosumnes restoration sites began to increase dramatically five to nine years after process-based restoration began and after ten years their number were still increasing. Other species, such as Bewick's Wren, may not increase in numbers until 10 years after restoration (Gardali et al. 2006). It is important to monitor the re-colonization of species to ensure the short- and long-term goals of a conservation action are met. After 15 years of annual monitoring, a less intensive monitoring program can be instituted (e.g., biennial monitoring). This less intensive approach to monitoring should be continued until the restoration reaches maturity. However, evaluating the influence of climate and/or

hydrology will necessitate annual monitoring due to the dynamic nature of the hydrology and weather characteristics and the marked response of bird populations.

Point count transects

For Cosumnes, we recommend surveying annually at the primary sites presented in Table 2, for the foreseeable future. The secondary sites should ideally be surveyed annually; however, in years with limited resources we recommend a more limited approach, as outlined above. For the purpose of measuring the progress of restoration sites we recommend monitoring for at least 15 years post-restoration. Bird species respond to restoration in predictable ways with some species (such as Common Yellowthroat, Song Sparrow, Blue Grosbeak and Lazuli Bunting) colonizing the site within the first five years post-restoration and other species appearing after 10 to 20 years. For example, woodpeckers, Western Wood-Pewee and Hutton's Vireo began to breed at Accidental Forest 15 years after process-based restoration began.

Table 2. Existing PRBO point count sites on the Cosumnes River Preserve recommended for continued avian monitoring.

| Site | Seral stage of riparian habitat | Restoration type |
|---|---|---|
| ***Primary sites*** | | |
| Tall Forest | Late-succession | None |
| Tall Forest West | Early-succession | Horticultural/process-based |
| Accidental Forest | Mid-succession | Process-based |
| Fallow Field | Early succession | Process-based |
| Valensin Forest | Late-succession | None |
| Middle Breach | Mid-succession | Process-based |
| Willow Slough | Mixed (early-late) | Horticultural/process-based |
| ***Secondary sites*** | | |
| Orr Forest | Late-succession | none |
| Greenfield | Early succession | Horticultural |
| Triangle Plot | Early succession | Horticultural/process-based |
| Wendel's Road | Mixed (early-mid) | Process-based |
| Wendel's Levee | Mixed (early-mid) | Process-based |

Mist netting sites

Two mist netting stations, Wilson's Section in Tall Forest and Wendel's Levee/Accidental Forest, were operated during the breeding season (May through July) for 11 years (1995 through 2005). We recommend continuing annual mist netting at these sites in order to determine adult survival rates and age structure for focal species. Information on survival rates can be combined with data on productivity to estimate population sustainability for focal species (Nur & Sydeman 1999).

Nest searching and monitoring plots

Nests were located and monitored throughout the Preserve but nest searching efforts were concentrated at six core sites. Two sites were in mature remnant habitat (Tall Forest and Orr Forest), one site was a process-based restoration site in a mid-successional stage (Accidental Forest), two sites were early successional process-based restoration (Middle Breach and Triangle Plot) and one site was a mix of horticultural and process-based riparian in an early successional stage (Tall Forest West). We recommend annual nest searching and monitoring at these core sites. At these sites, information on components of reproductive success should be collected and analyzed.

**Selecting study methods**

We recommend a multi-tiered approach to avian monitoring which includes point count surveys, nest searching and monitoring, territory mapping and mist netting (Ralph et al. 1993). These methods vary in intensity and scale and the type of information generated (e.g., abundance, distribution and/or demographics).

Point count surveys

The point count methodology provides information on the abundance and distribution (presence-absence) of birds and, over time, population trends. When combined with vegetation data, point count survey data can relate differences in bird metrics to differences in vegetation. This method covers a larger spatial scale than the other methods and requires the least amount

of effort making it ideal for large-scale inventories and projects with budget constraints. The five-minute variable circular plot point count method is a widely used survey method that allows for comparisons with other research projects nationwide.

Mist netting and banding

The capture and marking of birds in nets provides data on breeding condition and phenology and measures of individual fitness in the short term and survival of different age classes over the long-term. The ratio of young to adult captures for a given species also provides insight into productivity. In addition, capture rates provide an index to abundance. Bird habitat relationships, however, are limited using this method as the area sampled is not well-defined. Nationally standardized protocols are provided by MAPS (Monitoring Avian Productivity and Survival) and generally consist of operating ten 12-m nets in permanent locations for five morning hours per day for one day during each of ten consecutive 10-day intervals.

Territory mapping

The best means of estimating bird densities is the territory mapping method. Territory mapping involves recording multiple observations of individual territorial birds on detailed maps of the study area. Multiple observations of individuals that span the breeding season are combined and comprise a territory. To estimate density, territories are counted for a given species within a well-defined study area.

Nest searching and Monitoring

Direct measures of productivity for a given population require nest searching and monitoring. When combined with vegetation data collected at the nest, nest success, nest site selection and other life history traits can be related to vegetation characteristics. Nest monitoring is the most labor intensive of the four methods and has the smallest spatial scale (nest plots are typically 10 to 20 ha). Nest monitoring follows nationally standardized techniques and guidelines for locating and monitoring nests efficiently and with minimal disturbance to the birds are provided by Martin and Geupel (1993).

**Restoration, Research and Management Recommendations**

We provide restoration and management recommendations based on our results from 11 years of monitoring on the Cosumnes River as well as from other PRBO riparian studies from the Central Valley. Our results support many of the recommendations provided by the California Partners in Flight Riparian Bird Conservation Plan (RHJV 2004) where more detailed recommendations for are available (www.prbo.org/calpif/plans.html).

- **Increase floodplain connectivity and maximize winter flooding**

Several of the Cosumnes focal species (Common Yellowthroat, Song Sparrow and Blue Grosbeak) prefer to nest in early successional habitat with dense understory cover. Early successional riparian habitat is dependent on floodplain connectivity and seasonal flooding which includes scouring, soil deposition and point bar formation. Results from the Cosumnes study show a positive correlation between Tree Swallow abundance during the breeding season and the number of winter flood days. In addition, Song Sparrow nest success in restored areas was also positively correlated with the number of winter flood days.

- **Manage for a mosaic of riparian habitat in different seral stages.**

The importance of early successional riparian habitat cannot be overstated. The goals of conservation actions are often to re-create mature gallery forest. However, many bird species (Lazuli Bunting, Song Sparrow, Common Yellowthroat, Blue Grosbeak, Least Bell's Vireo and others) either occur in low numbers or are absent in mature gallery forests. These species depend on early successional riparian habitat and are negatively correlated with characteristics associated with mature riparian (e.g., high canopy cover). We recommend managing for a mosaic of early, mid, and late successional habitat to benefit the full complement of riparian bird species.

- **Increase tree species richness**

Planting or managing for high tree species diversity, especially large trees, will benefit many different bird species. Results from another songbird study in the San Joaquin Valley (Wood 2005) show that Bushtit and Western Scrub-Jay are positively correlated with tree species

richness and studies from other sites (Nur et al. 2005) show a similar relationship with tree species richness and/or tree size (exemplified by House Wren and Tree Swallow, the latter a Neotropical migrant).

- **Increase understory plant volume and diversity**

We recommend managing for understory growth particularly of herbaceous plants. This has been shown to be important to riparian birds in other studies (Holmes et al. 1999, DiGaudio 2001, Wood 2005, Nur et al. 2005). Mowing and spraying for weed control (e.g., Himalayan blackberry, *Rubus discolor*) at a site will necessarily reduce understory volume. The decision to mow should be carefully considered as a compromise between the need for weed control to promote a well-developed native understory over the long-term and the need to provide vegetative cover for ground-nesting birds during the important early successional stage of a restoration area.

- **Nest predator studies**

We recommend studies of nest predators to better understand this threat and how it may be mediated by flooding and weather variables. Such studies will allow specific management actions to be formulated and evaluated that can mitigate predation rates. Recommended studies include continued nest monitoring using cameras to identify nest predators and quantify predation rates and Brown-headed cowbird activity at focal species' nests. We also recommend analysis of nest survival and predation rates for all study species, especially for species that are currently declining in mature habitat. In addition, studies are needed to characterize predation risk (and the timing of predation) in relation to vegetation at or near the nest, as well as proximity of the nest to habitat edges (upland and river). A preliminary nest camera study at the Cosumnes River Preserve identified Brown-headed Cowbirds and black rats (*Rattus rattus*) as important nest predators (J. Hammond In prep.). Of 19 Song Sparrow nests monitored using cameras, 10 were depredated (6 by black rat [R. rattus] and 4 by Brown-headed Cowbird).

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