

Bibkey # 550048
G 06A

SONGBIRD USE OF REDWOOD AND LAGUNITAS CREEKS: MANAGEMENT AND RESTORATION RECOMMENDATIONS



**Report
to the Golden Gate National Recreation Area**

Prepared by

Thomas Gardali, Sandra E. Scoggin, and Geoffrey R. Geupel

**of the Point Reyes Bird Observatory
Stinson Beach, CA 94970**

**tgardali@prbo.org
ggeupel@prbo.org**

January 1999

Abstract: We investigated the nesting success of songbird species breeding in two riparian drainages (Redwood and Lagunitas Creeks) in the Golden Gate National Recreation Area, Marin County, California. Estimates of nest success are presented for 14 species nesting in both drainages. Nest success was low for the majority of open-cup nesting species in contrast to the relatively high nest success of cavity-nesters. In order to guide restoration efforts for Redwood Creek we examined structural and floristic vegetation characteristics that may influence nesting success for Warbling Vireo (*Vireo gilvus*), Swainson's Thrush (*Catharus ustulatus*), Wilson's Warbler (*Wilsonia pusilla*), and Song Sparrow (*Melospiza melodia*) using data from the 1997 and 1998 field seasons. Univariate models are presented for all four species and multivariate models are presented for Song Sparrow and Swainson's Thrush in order to determine which variables influence nest success. System-wide structural diversity and two tree species, red alder and California bay, were important variables influencing nest success. Nesting substrate preferences are presented for five species as well as all species combined. California blackberry, willow, sword fern, lady fern, and red elderberry were important nest substrate preferences. Management and restoration recommendations are presented.

INTRODUCTION

Declines in North American songbird populations have led to widespread efforts to identify the causes of population fluctuations and suggest management options to help reverse these declines (Hagen and Johnston 1992). The few long-term studies of migrant landbirds in California suggest that populations are being limited by reproductive success on the breeding grounds (Johnson and Geupel 1996, Chase et al. 1997). Understanding the impact of non-native plant species on breeding songbirds as well as collecting baseline information to evaluate and guide restoration efforts will help reverse these declines.

The Golden Gate National Recreation Area (GOGA) is committed to the restoration of the Redwood Creek watershed. GOGA has identified the removal and containment of Cape-ivy (*Delairea odorata*) as their top vegetation management priority. Cape-ivy is an invasive introduced plant species infesting 40 acres at Redwood Creek and is in the early stages of infestation at Lagunitas Creek. In addition, active restoration of the Redwood Creek Watershed is slated to occur in the near future. The Point Reyes Bird Observatory (PRBO) and GOGA have collected baseline data on songbird productivity and associated habitat characteristics since 1997 which allow us to guide and evaluate restoration activities.

For the purpose of establishing correlates of primary population parameters with habitat characteristics, data from Lagunitas and Redwood Creeks were combined in order to increase sample size, thus to better understand the mechanisms determining nesting success in songbird species representative of riparian areas in coastal Marin County. Less intensive monitoring by point counts was conducted within GOGA in 1998, the results of which are presented in a separate document (see Holmes et al. 1999).

This report provides management and restoration recommendations for resident and Neotropical migrant songbirds in two riparian areas within GOGA.

METHODS

All sites are located within GOGA in western Marin County, California. In 1998 we added 8 new point count stations at Redwood Creek that correspond with a new nest monitoring plot.

Nest Monitoring

Nest monitoring provides direct information on both productivity and habitat conditions that facilitate maintenance of viable populations, thereby providing direct land management information. Examination of nests also allows collection of life history data (e.g., clutch size, number of broods, numbers of nesting attempts), which provide important insight into vulnerability of species to decimation or perturbations (Martin and Geupel 1993).

Nest finding and monitoring followed specific guidelines in Martin and Geupel (1993). Nest Monitoring occurred at two sites (Lagunitas Creek and Redwood Creek). Lagunitas Creek was composed of two plots, Lagunitas Creek A (LCA) and Lagunitas Creek B (LCB) approximately 800m x 45m or 3.6 hectares. Redwood Creek was composed of three plots: Muir Beach (MB), Redwood Creek A (RCA), and Redwood Creek B (RCB) of approximately the same size. Nest finding began in early April and lasted until breeding activity severely declined in late July. Plots were searched at least every four days, and individual nests were checked at least every four days until outcome could be determined. Outcome could usually be determined by conditions at the nest or by observing fledglings near the nest. Nests were located at all stages (construction, egg-laying, incubation, and nestling stage). Upon finding a nest various data were recorded directly onto a "nest record sheet." Types of data include: number of eggs or young, nest attempt, cue used to find nest, and parental elusiveness. Basic measurement of the nest and nest substrate were also recorded on the "nest record sheet" after outcome was determined. Examples include: nest height, plant height, plant species, and number of support branches. For a complete list of data variables see Martin and Conway (1995). More detailed measurements of vegetation associated with the nest were recorded separately, see section below. Nests were checked carefully to minimize human disturbance. These precautionary measures include: keeping visits brief, minimizing disturbance to area around nest (for example, avoid creating a dead end trail to nest), and staying clear of nest sites when predators were detected nearby (Martin and Geupel 1993).

All data from nest monitoring was recorded and entered in a format compatible with the "Breeding Biology Research and Monitoring Database (BBIRD)" program run out of the Fish and Wildlife Service Cooperative Unit at the University of Montana (Martin and Conway 1995).

Territory Mapping

The territory mapping method is based on territorial behavior of birds. By marking the locations of observed birds on a detailed map throughout the breeding season, it is possible to count the number of territories in an area and estimate the density of birds.

Territory mapping was conducted at the five nest plots and followed International Bird Census Committee recommendations (IBCC 1970). The same observer visited each plot at least 8 times during the breeding season (April-July), and territorial individuals were mapped.

Vegetation Assessment

As soon as a nesting attempt terminated (successful or unsuccessful) we measured the vegetation associated with the nest substrate and surrounding patch. We used a slightly modified version of the BBIRD method (Martin and Conway 1995) for vegetation measurements which included the addition of a section for forb cover and height by species. The basic units for vegetation sampling were a 5 m radius plot (for shrubs and forbs) and an 11.3 m radius plot (for trees) centered on the nest. The plot was divided into 4 quadrants to facilitate our measurements and estimations. Stems of all shrubs were counted by species within each 5 m radius plot at 10 cm above the ground. The number of stems of each shrub species was counted for each of two size classes (<2.5 cm diameter or >2.5 cm diameter). For each of the four quadrants in the plot we made visual estimates of percent vegetation, bare ground, water, logs or stumps, and litter.

Vegetation was also sampled at the plot level utilizing the point count locations as plot vegetation points. Four subpoints were established at each plot vegetation sampling point (point count location). A "nest" vegetation assessment was done at each point count location (as described above) and the point-centered quarter method (Mueller-Dombois and Ellenberg 1974) was done at each subpoint. The point-centered quarter method is used to estimate densities of woody plants. These assessments were completed for MB, RCA, LCA, and LCB in 1997 and for RCB in 1998.

Target Species

Special attention was given to four species for the logistic regression analyses: Swainson's Thrush, Warbling Vireo, Wilson's Warbler, and Song Sparrow. We chose to focus on these species, three of which are understory nesters, and one (Warbling Vireo), which is a canopy nester for four reasons: 1) All of them are statewide riparian priority species as defined by California Partners in Flight (CPIF); 2) Song Sparrow, Swainson's Thrush, and Wilson's Warbler are the most abundant species breeding on our Redwood and Lagunitas Creek nest plots, and by including the Warbling Vireo, were able to make management recommendations for a canopy nester; 3) the largest nest samples sizes from the 1997 and 1998 seasons are for these species', and 4) these 4 species have a high percent mean similarity in proportional abundance between all PRBO study sites in GOGA enabling an increase in sample size and statistical power for data analyses. An additional species (added as an afterthought), the Black-headed Grosbeak, was examined for nest substrate preferences (only) because: it is also a riparian species of concern

(CPIF), a suitable sample size was obtained, and it occupies a nesting zone somewhere between the understory and canopy.

Statistical Analysis

Nest success was calculated using Mayfield (1975) as recommended by Johnson (1979). Mayfield (1975) estimates of nest success are better estimates of nest survivorship in that they take into account sample size and number of observation days and offers the advantage of correcting for the fact that nests in any sample are likely to be found at various stages in the nest cycle. Nests found early in the nest cycle have a higher probability of failure, and since a sample may contain quite a few nests found in the late stages of the nest cycle, limiting analysis to proportion successful can lead to biased results which overestimate nest success (Martin 1993).

We used logistic regression to investigate nesting success in relation to habitat variables for 4 of our target species. Logistic regression is used to model the effects of independent variables on a binary response (such as successful/unsuccessful) (McCullagh and Nelder 1989). We developed predictive models using stepwise multiple logistic regression. Terms that were significant in univariate regressions were entered into a stepwise elimination strategy. We used the likelihood ratio statistic to test hypotheses, which is analogous to sums of squares in ANOVA. In multiple logistic regression models, independent terms are reported using a likelihood ratio test. All models presented here were tested using the Hosmer-Lemeshow goodness of fit χ^2 test ($P > 0.05$).

RESULTS

Nest Data

We located and monitored 228 nests for 30 species on five riparian plots—MB, RCA, RCB, LCA, and LCB. Nest success calculations, as described below, are combined with mortality factors in Table 1. Only nests with known outcomes are included.

Nest Success

Nest success was calculated in two ways (after Martin 1992): 1) "Proportion Successful," a percentage of successful nests out of all nests located for that species, and 2) "Estimated Nest Success," using the Mayfield method (1975), which calculates the probability of nest success based on the daily survival rate of the given sample of nests. See Appendix 1 for Mayfield estimates of nest survivorship. See Appendix 2 for proportional nest success for all species whose nests were located.

Mortality Factors

Predation was divided into the three categories presented in Table 1. The first two categories included all nests where damage to the nest structure could be determined. 1) Predation without damage: nests with no damage are considered to be preyed upon by birds, snakes, or small mammals (Best and Stauffer, 1980). Predation by Western Scrub-jays (*Aphelocoma coerulescens*) and Steller's Jays (*Cyanocitta stelleri*) was witnessed at each site and distress and aggression towards Jays was observed frequently. 2) Predation with damage: nests with damage to the nest structure are considered to be preyed upon by larger mammals (Best and Stauffer, 1980). 3) Nests which could not be checked for damage. This included canopy and cavity nests which could not be readily observed. Also included in Table 1 are proportions of nests that failed due to Brown-headed Cowbird (*Molothrus ater*) parasitism. The final category combines proportions of nests that failed due to weather-related causes, trampling, human related causes, abandonment with no contents, structural failure and unknown causes (e.g. late storms and GOGA trail maintenance activities).

TABLE 1. Nesting success and sources of mortality for Redwood and Lagunitas Creeks combined, 1998.

Species	<i>n</i> ^a	Nest Succ. Prop. ^b	Mayf Est. ^c	Nest Pred. Damage ^d	Nest Pred. w/o Damage ^e	Nest Pred. ^f	Fail Cowb. ^g	Aband. w/cont. ^h	Other ⁱ
Anna's Hummingbird	4	0.75	-	0	0.25	-	0	0	0
Allen's Hummingbird	10	0.20	0.31	0.50	0.10	-	0	0.10	0.10
Western Wood-pewee	4	1.00	-	0	0	-	0	0	0
Black Phoebe	7	0.86	-	0.14	0	-	0	0	0
Warbling Vireo	12	0.08	0.06	Unk.	unk.	0.75	0.08	0	0.08
Bushtit	12	0.33	-	0.33	0.17	-	0	0	0.17
Swainson's Thrush	21	0.29	0.07	0.14	0.48	-	0	0	0.10
American Robin	26	0.31	0.21	Unk.	unk.	0.54	0	0	0.15
Wilson's Warbler	19	0.05	0.10	0.32	0.32	-	0.16	0	0.11
California Towhee	9	0.56	0.24	0.44	0	-	0	0	0
Song Sparrow	43	0.42	0.24	0.16	0.28	-	0	0.07	0.05
Black-headed Grosbeak	15	0.33	0.27	0.20	0.47	-	0	0	0
House Finch	4	0	-	0	0.75	-	0	0	0.25
American Goldfinch	3	0.33	-	0.33	0.33	-	0	0	0
Cavity Nests	22	0.85	-	-	-	0.15	0	0	0
All Other Nests	14	0.57	-	-	-	0.36	0	0	0.07

- Number of nests, all plots combined.
- Proportional success for nests with determined outcome.
- Mayfield estimates for species with usable sample size of nine and above-all sites combined.
- Proportion of nests lost to nest predation with damage to the nest structure.
- Proportion of nests lost to nest predation, no damage to the nest structure.
- Proportion of nests lost to nest predation, damage to nest structure indeterminate.
- Proportion of nests that failed due to parasitism by Brown-headed Cowbirds.
- Proportion of nests abandoned with contents.
- Proportion of nests failed from weather related causes, trampling, human related causes, abandonment with no contents, structural failure or unknown causes.

Cowbird Parasitism

Nests were inspected for eggs and young of the Brown-headed Cowbird. Of the 30 species for which nests were located in 1998, 5 species (17%) were confirmed to be parasitized by Brown-headed Cowbirds. In 1997, the same 5 species (21%) were also parasitized. Nest data from all plots combined for each year (1997 and 1998), including proportion parasitized, proportion parasitized and successful, proportion fledging Brown-headed Cowbird young, and proportion abandoned or failed as a result of parasitism are presented in Table 2. We were unable to check contents for most species of canopy and cavity nesters, so actual rates are likely to be underestimated. Cowbirds are known to lower the reproductive success of their hosts (Payne 1977).

TABLE 2. 1997 and 1998-all sites. Number of nests located for parasitized species, proportion parasitized, proportion parasitized and successfully fledging host young, proportion parasitized and fledging cowbird young, and proportion abandoned or failed as a result of parasitism

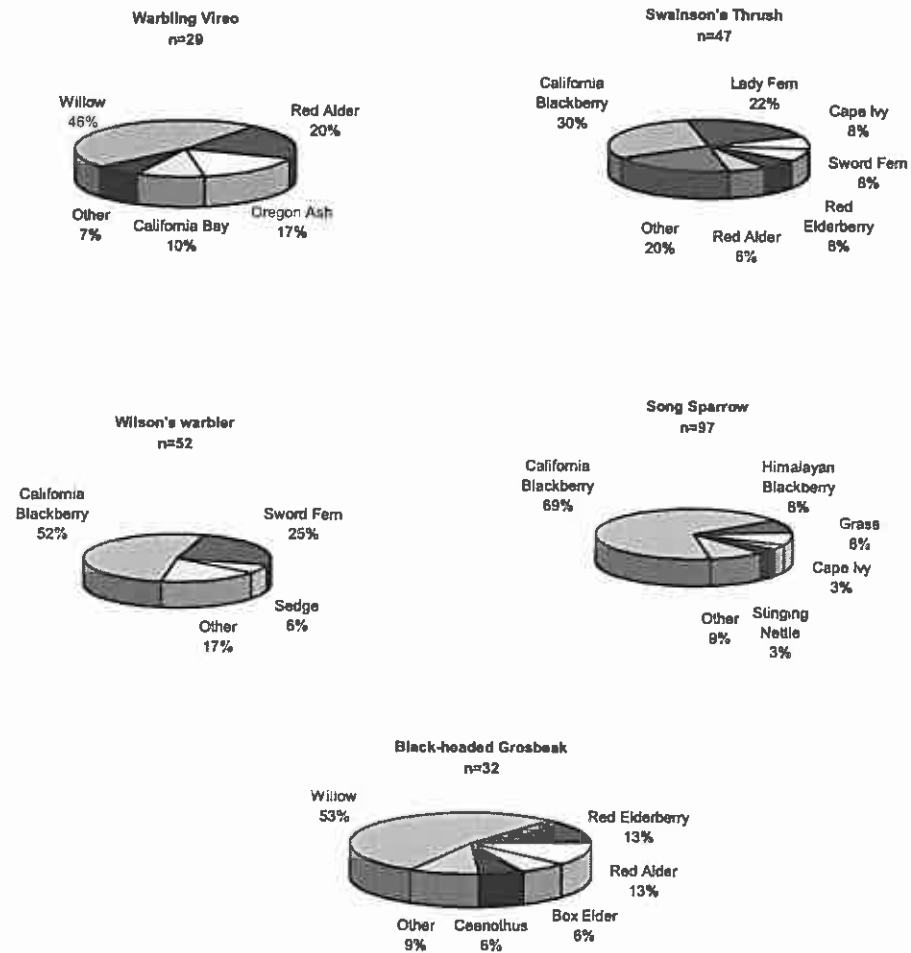
Species	Number of Nests		Proportion Parasitized		Parasitized/ Successful		Fledged Cowbird		Abandoned/ Failed (result of parasitism)	
	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998
Warbling Vireo	12	12	0.08	0.08	0	0	0.08	0.08	0.08	0.08
Swainson's Thrush	17	21	0.06	0.10	0	0.10	0	0	0	0
Wilson's Warbler	15	19	0.47	0.37	0	0	0	0	.13	0.16
Song Sparrow	29	43	0.17	0.12	0.07	0	0.07	0	0	0
American Goldfinch	5	3	0.20	0.33	0	0	0	0	0.20	0
TOTAL	78	101	0.19	0.16	0.03	0.02	0.04	0.01	0.05	0.04

Nest Substrate for Target Species

The proportions of primary nest substrates are presented in Figure 1 for all five target species at Lagunitas Creek and Redwood Creek combined. We combined data collected by PRBO biologists in 1997 and 1998 with data collected by Kern River Research Center (KRRC) biologists in 1995 and 1996.

California blackberry (*Rubus ursinus*) was the favored substrate for three of the five target species: Swainson's Thrush (30%), Wilson's Warbler (52%), and Song Sparrow (69%). The other two favored willow species (*Salix sp.*): Warbling Vireo (46%) and Black-headed Grosbeak (53%). Two types of ferns were important nest substrates: Swainson's Thrush chose lady fern (*Athyrium filix-femina*) for 22% of their nests and Wilson's Warbler chose sword fern (*Polystichum munitum*) for 25% of their nests.

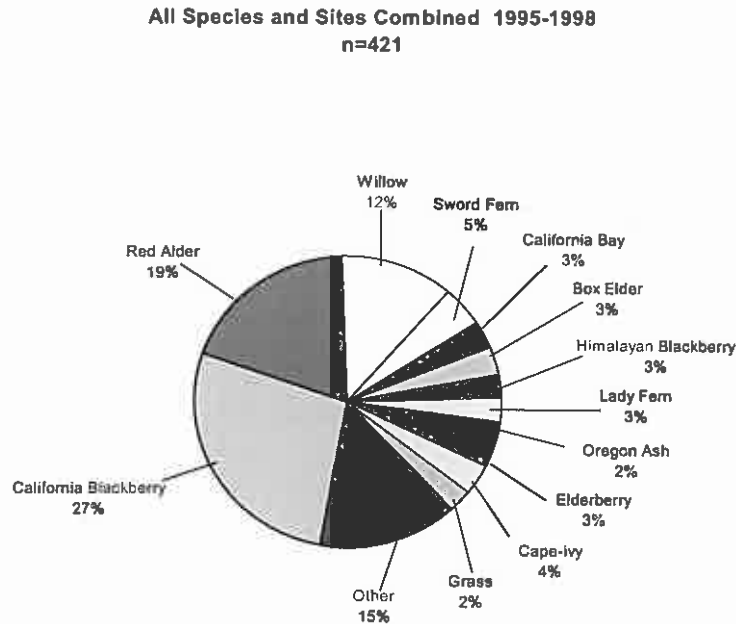
FIGURE 1. Nest substrate selection for five target species at Lagunitas Creek and Redwood Creek combined, 1995-1998.



Nest Substrate for All Species

The proportions of primary nest substrates for all nests found at Lagunitas Creek and Redwood Creek from 1995 through 1998 (excluding nests in banks or on human-made structures) are presented in Figure 2. We combined data collected by PRBO biologists in 1997 and 1998 with data collected by KRRC biologists in 1995 and 1996. California blackberry, red alder (*Alnus rubra*), and willow species were the three most important substrates, supporting 58% of the nests.

FIGURE 2. Nest substrate selection for all species at Lagunitas Creek and Redwood Creek combined, 1995-1998.



Effect of Surrounding Vegetation on Nest Success

Vegetation data collected around each nest site was used to compare successful to unsuccessful nests in 1997 and 1998. The proportion of successful nests of Song Sparrow, Swainson's Thrush, Wilson's Warbler and Warbling Vireo were used in these analyses. Logistic regression was used to identify significant correlates. Only models that passed the goodness-of-fit test are presented. A total of 230 variables representing the structural and floristic environment of the nest site were investigated to determine whether they influence nest success. See Appendix 4 for a list of the habitat variables.

Song Sparrow

For Song Sparrow, litter depth, small red alder trees and total red alder trees were all significantly correlated with successful nests. There were no variables that showed a negative influence (Table 3). Successful Song Sparrow nests had a mean of 4.5 red alder trees within 11.3 m of the nest while unsuccessful nests had 1.5. When we put all of the significant univariate variables into a stepwise logistic regression model total red alder trees and litter depth remained important (Table 4).

TABLE 3. Variables influencing Song Sparrow nest success (Univariate).

Variable	Regression Coefficient	Standard Error	P Value	Pseudo r^2
Litter depth	0.02	0.01	0.01	0.06
Small red alder trees (8-23 dbh)	0.23	0.16	0.03	0.04
Total red alder trees	0.12	0.06	0.01	0.05

TABLE 4. Variables influencing Song Sparrow nest success (Multivariate).

Number of nests = 70			
LRS(2) = 10.91			
P>chi ² = 0.004			
Pseudo r^2 = 0.11			
Dependent variable: nest success of Song Sparrow			
Variable	Regression Coefficient	Standard Error	P Value
Total red alder trees	0.10	0.05	0.02
Litter depth	0.02	0.01	0.02

Swainson's Thrush

Swainson's Thrush nesting success was only positively influenced by 2 variables, small red alder trees and total red alder trees. However, when we repeated the analysis after dropping the outlying data point the results were not significant. Seven variables had a negative influence, most notably all snags and tree species richness (Table 5). When we put all of the significant univariate variables into a stepwise logistic regression model total number of snags, shrub richness and forbs as ground cover remained important negative predictors of nest success (Table 6).

TABLE 5. Variables influencing Swainson's Thrush nest success (Univariate).

Variable	Regression Coefficient	Standard Error	P Value	Pseudo r^2
Small red alder trees (8-23 dbh)	0.10	0.11	0.02	0.12
Total red alder trees	0.05	0.03	0.05	0.08
Tree species richness	-1.08	0.52	0.02	0.12
Shrub species richness	-0.82	0.40	0.02	0.12
All large trees (>38 dbh)	-0.32	0.19	0.05	0.09
All snags	-1.04	0.67	0.02	0.12
Total green ground cover	-0.03	0.01	0.04	0.09
Forb as ground cover	-0.04	0.02	0.03	0.10
Litter depth	-0.06	0.03	0.02	0.11

TABLE 6. Variables influencing Swainson's Thrush nest success (Multivariate).

Number of nests = 34	Dependent variable: nest success of Swainson's Thrush
LRS (3) = 21.02	
$P > \chi^2 = 0.001$	
Pseudo $r^2 = 0.51$	

Variable	Regression Coefficient	Standard Error	P Value
Total number of snags	-1.86	0.99	0.009
Forb as ground cover	-0.08	0.04	0.001
Shrub richness	-1.89	0.81	0.0009

Warbling Vireo

There were no variables that positively influenced Warbling Vireo nest success (Table 7). Nest height was the most powerful predictor of nest success, the higher the nest the higher the probability of failure. Mean nest height of successful nests was 4.5 m and 9.71 m for unsuccessful.

TABLE 7. Variables influencing Warbling Vireo nest success (Univariate).

Variable	Regression Coefficient	Standard Error	P Value	Pseudo r^2
Height of nest tree	-0.33	0.23	0.05	0.20
Nest height	-1.10	0.59	0.002	0.51
Shrub as ground cover	-0.66	0.45	0.04	0.21
Forb as ground cover	-1.14	1.12	0.01	0.36

Wilson's Warbler

Large California bay (*Umbellularia californica*) trees and total California bay trees positively influenced Wilson's Warbler nesting success (Table 8). The mean numbers of bays around successful nests were 2.5 and only .37 for unsuccessful nests.

TABLE 8. Variables influencing Wilson's Warbler nest success (Univariate).

Variable	Regression Coefficient	Standard Error	P Value	Pseudo r^2
Large California bay trees (>38 dbh)	1.57	0.83	0.01	0.41
Total California bay trees	0.33	0.17	0.01	0.41

Nest Timing

The mean range of date of first egg laid (including standard error) for five target species (Warbling Vireo, Swainson's Thrush, Wilson's Warbler, Song Sparrow, and Black-headed Grosbeak) is presented in Table 9 using data collected in 1997 and 1998 combined. Also shown is the range in number of days in between the earliest first egg and the latest first egg.

The earliest date of first egg laid was March 19 and the latest was July 6. The earliest egg was laid by a Song Sparrow, a resident species that possesses the widest latitude in nest initiation timing. The other four species, which are Neotropical migrants, exhibited narrower time frames for nest initiation. Prior to laying a first egg, each species spends time selecting a nest site and constructing the nest. After laying a first egg, it requires at least a month for a pair to raise and successfully fledge a brood of young. The breeding season at Lagunitas Creek and Redwood Creek begins approximately in mid-March and extends into mid-August. This range should be taken into account when planning trail maintenance and other management activities, with particular attention given to avoiding disturbance during the peak of the breeding season (represented by the mean date of first egg).

TABLE 9. Timing of nest initiation, based on date of first egg laid for five target species at Lagunitas Creek and Redwood Creek in 1997 and 1998.

Species	<i>n</i>	Mean date of first egg (SE)	Earliest first egg	Latest first egg
Warbling Vireo	19	5/20 (4.2)	4/23	6/23
Swainson's Thrush	33	6/10 (2.4)	5/11	7/6
Wilson's Warbler	24	5/24 (3.6)	5/3	6/24
Song Sparrow	72	4/30 (3.2)	3/19	6/29
Black-headed Grosbeak	21	5/17 (3.6)	4/17	6/14

Territory Mapping

Territory mapping provides data on actual densities of birds in an area. Tables of the number of territories mapped for each species on each plot are presented in Appendix 3. Territories were mapped for a number of species whose nests were not located during nest monitoring efforts. Song Sparrows were the most abundant species at all nest plots.

RECOMMENDATIONS: For riparian songbird habitat enhancement

1. **Recommendation:** Limit trail and other maintenance activities that involve vegetation clearing or cutting to the non-breeding season (mid March to mid August). Planned disturbance events should be timed to minimize impact to nesting bird species. At least 3 nests under observation were lost to trail maintenance activities during the 1998 breeding season.
2. **Recommendation:** Increase tree species richness by planting red alder, willow, and California bay in suitable areas. Small and total red alder trees showed a positive influence on the nesting success of Song Sparrows and Swainson's Thrushes. Large California bay trees positively influenced the nesting success of Wilson's Warblers. Willows were important nest substrates for 12% of all species sampled from 1995-1998 and were predominantly used (~50%) by Black-headed Grosbeaks and Warbling Vireos.
 - 2.a. **Recommendation:** Plant tree species to restore riparian forest structure. California bay should be planted where the upland (mixed hardwoods) grades into the riparian forest. The mean number of bays around successful Wilson's Warbler nests was 2.5 and only .37 for unsuccessful nests (11.3 m radius). Plant "shrubby" willows in patches (clumps) in wet areas or areas that flood (or have the potential to). Concentrated plantings will create usable habitat quickly while at the same time mimicking a "founder effect" in which succession is not linear, but can be determined on the basis of the type of vegetation that becomes established subsequent to scouring or deposition (RHJV 1998). To recreate currently occurring red alder densities, plant at varying intervals (from 1 – 25 m) but at an average of 6 – 7 m ($6.37 \text{ m} \pm 1.14$, $n = 25$). This will also allow space for the propagation of understory plant species (see below). Successful Song Sparrow nests had a mean of 4.5 red alder trees within 11.3 m of the nest while unsuccessful nests had 1.5.
3. **Recommendation:** Increase understory foliage volume by planting California blackberry, willow, sword fern, lady fern, and red elderberry (*Sambucus racemosa*). These plant species were important nesting substrates for many species whose nests were located from 1995-1998. Elderberry in the Sacramento Valley (*Sambucus mexicana*) positively influenced the nesting success of the Lazuli Bunting (*Passerina amoena*) and showed a positive relationship to bird diversity (when elderberry cover was over 25 % species diversity nearly doubled) (Geupel et al. 1997).
 - 3.a. **Recommendation:** Plant understory plant species in suitable and appropriate areas to restore riparian forest structure. Plant understory species below existing tree canopy where removal of non-native plants species has occurred and in between new tree plantings. In general, sword fern grows in the upper/dryer areas while lady fern is found more commonly at the stream edges or in the floodplain. California blackberry occurs throughout the watershed as large patches in forest openings and as dense "mats" below tree canopy.
4. **Recommendation:** Promote system-wide high structural diversity. As supported by this study the presence of early to late successional stages of riparian woodland

systems have been identified as key features for the successful management of riparian bird communities (RHJV 1998). For example, Warbling Vireos prefer to establish territories in areas with large trees but have higher nesting success when nest placement is lower in smaller trees. The importance of small red alder trees for both Song Sparrows and Swainson's Thrushes suggests improved productivity in early successional habitats (non-willow).

5. **Recommendation:** Remove non-native plant species. Non-native plant species have the potential to decrease structural diversity by decreasing plant species richness (Alvarez and Cushman 1997). Structural diversity is an important habitat characteristic for reproductive success (see Recommendation # 4). In addition, a diverse shrub layer had a positive influence on bird species richness and diversity in GOGA and the Point Reyes National Seashore (Holmes et al. 1999).
6. **Recommendation:** Protect and restore adjacent upland habitats. Upland areas adjacent to riparian corridors may be of critical importance to the maintenance of healthy bird populations. Some species may benefit from a contiguous transition from lowland riparian to upland mixed hardwoods or coastal scrub. For example, we may interpret the positive relationship between Wilson's Warbler nest success and California bay as testimony to the importance of adjacent habitats.
7. **Recommendation:** Manage adjacent habitats and educate private landowners. Human habitation and cattle pastures adjacent to riparian areas may have a negative influence on songbird communities. Grazed areas, mown lawns, feed-lots, bird feeders, open trash cans, and unkempt picnic areas provide an abundant food source for the Brown-headed Cowbird as well as nest predators such as jays, raccoons, and skunks. These food sources attract predator species and may facilitate their over-winter survival by supplying food at a time where it would normally be in short supply (Boarman 1993). We observed Common Ravens (*Corvus corax*) feeding at the Muir Beach picnic area on many occasions.

PERSONNEL

Project manager Thomas Gardali and field biologists Sue Abbott, Aaron Crawford, and Sandra Scoggin conducted all fieldwork under the supervision of Terrestrial Program director Geoffrey R. Geupel.

ACKNOWLEDGMENTS

We are indebted to field biologists Sue Abbott and Aaron Crawford for long hours in the field and office, Aaron Holmes for assistance in preparation of this report, Grant Ballard and Mike Lynes for technical support, volunteer Kyria Ramey for assistance in vegetation data collection, and to Daphne Hatch for her support of songbird monitoring in the Golden Gate National Recreation Area. This project was funded in part by the National Park Service fee demonstration project and the Golden Gate National Parks Association. This is PRBO contribution number 903.

LITERATURE CITED

- Alvarez, M. E. and J. H. Cushman. 1997. The effect of an introduced plant species on three coastal plant communities. *Bull. Ecol. Soc.*
- Best, L.B. and D.F. Stauffer. 1980. Factors affecting nesting success in riparian bird communities. *Condor* 82: 149-158.
- Boarman, W. I. 1993. When a native predator becomes a pest: A case study. *In* Conservation and Resource Management. Majumdar, S.K., E.W. Miller, D.E. Baker, E.K. Brown, J.R. Pratt, and R.F. Schmalz (editors). The Pennsylvania Academy of Science.
- Chase, M. K., N. Nur, and G. R. Geupel. 1997. Survival, productivity, and abundance in a Wilson's Warbler population. *Auk* 114: 354-356.
- Geupel, G. R., G. Ballard, N. Nur, and A. King. 1997. Population status and habitat associations of songbirds along riparian corridors of the lower Sacramento River: Results from the 1995 field season and summary of results 1993 to 1995. PRBO unpublished report to The USFWS and The Nature Conservancy. Stinson Beach, CA.
- Hagan, J. M. III, and D. W. Johnston (Eds.). 1992. Ecology and conservation of Neotropical migrant landbirds. Smithsonian Institution Press, Washington, D. C.
- Holmes, A., D. L. Humple, T. Gardali, and G. R. Geupel. 1999. Songbird monitoring by point count in the Point Reyes National Seashore and the Golden Gate National Recreation Area: Results and recommendations from the 1998 season. Unpublished DRAFT report to the Point Reyes National Seashore and the Golden Gate National Recreation Area.
- I.B.C.C. (International Bird Census Committee) 1970. An international standard for a mapping method in bird census work recommended by the International Bird Census Committee. *Audubon Field Notes* 24:722-726.
- Johnson, M. D. and G. R. Geupel. 1996. The importance of productivity to the dynamics of a Swainson's Thrush population. *Condor* 98: 133-141.

- Johnson, D. H. 1979. Estimating nest success: The Mayfield method and an alternative. *Auk* 96: 651-661.
- Martin, T. E. 1993. Nest Predation and nest sites: New perspectives on old patterns. *Bioscience* 43: 523-532.
- Martin, T. E. 1992. Breeding productivity considerations: What are the appropriate habitat features for management? Pg. 455-473 in J.M. Hagan and D.W. Johnston (editors) *Ecology and Conservation of Neotropical Migrant Birds*. Smithsonian Inst. Press, Washington, D.C.
- Martin, T. E. and C. Conway 1995. BBIRD Field Protocol: Breeding Biology Research and Monitoring Database. Montana Coop. Wildl. Res. Unit, Missoula, MT. March 1995. 39pp.
- Martin, T. E. and G. R. Geupel. 1993. Nest monitoring plots: Methods for locating nests and monitoring success. *J. Field Ornith.* 64: 507-519.
- Mayfield, H. F. 1975. Suggestions for calculating nest success. *Wilson Bull.* 87: 456-466.
- McCullagh, P., and J. A. Nelder. 1989. *Generalized linear models*. Chapman and Hall, New York
- Mueller-Dombois, E. and H. Ellenberg 1974. *Aims and methods of vegetation ecology*. John Wiley & Sons, New York. 547pp.
- Payne, R. B. 1977. The ecology of brood parasitism in birds. *Annu. Rev. Ecol. Syst.* 8: 1-28.
- RHJV (Riparian Habitat Joint Venture). 1998. *The Riparian Bird Conservation Plan: A Strategy for Arresting the Decline of Birds and Associated Riparian Species in California*. Calif. Partners in Flight. <http://www.prbo.org/CPIF/Riparian/Riparian.html>.

APPENDIX 1. Mayfield estimates of nest survivorship, standard error, and daily survivorship for eight species (all nest plots combined).

Species	Number of Nests	Total Nest Success (Standard Error)	Daily Survivorship
Allen's Hummingbird	9	0.31(0.013)	0.973
Warbling Vireo	10	0.07(0.026)	0.918
Swainson's Thrush	19	0.07(0.022)	0.916
American Robin	21	0.21(0.013)	0.951
Wilson's Warbler	13	0.10(0.023)	0.916
California Towhee	9	0.24(0.025)	0.949
Song Sparrow	42	0.24(0.011)	0.945
Black-headed Grosbeak	15	0.27(0.014)	0.954

APPENDIX 2. Total number of nests monitored by species with sample size of at least 9 and proportion successful by site and all sites combined.

TABLE 1. Only open-cup nesting species with sample sizes of 9 and above are presented. Open-cup nesting species are underlined. All cavity nesting species were included and totaled. Cavity nesting species are marked with an asterisk*. Target species are shown in **bold**.

Species	Number of Nests	Proportion Successful	# with Unknown Outcome
<u>Allen's Hummingbird</u>	10	0.20	0
Downy Woodpecker*	6	1.00	0
Hairy Woodpecker*	1	0	0
Red-shafted Flicker*	2	0.50	0
<u>Warbling Vireo</u>	13	0.08	1
Tree Swallow*	2	1.00	0
Chestnut-backed Chickadee*	7	1.00	1
Bushtit	12	0.33	0
Pygmy Nuthatch*	3	1.00	1
Western Bluebird*	1	0	0
<u>Swainson's Thrush</u>	22	0.29	1
<u>American Robin</u>	26	0.31	0
<u>Wilson's Warbler</u>	19	0.05	0
<u>California Towhee</u>	9	0.56	0
<u>Song Sparrow</u>	44	0.42	1
<u>Black-headed Grosbeak</u>	15	0.33	0
Total Nests (all species)	228	0.39	5
Total Cavity Nests	22	0.85	2
Total Cup Nests	193	0.35	3
Total Pendulum Nests	13	0.38	0

APPENDIX 2. (continued).

TABLE 2. Number of nests located for each species at **Muir Beach** in 1998, proportion successful, and number of nests with undetermined outcome. Cavity nesting species are marked with an asterisk*. Pendulum nesting species are marked with two asterisks**. All other species are open cup nesters. Target species are shown in **bold**.

Species	Number of Nests	Proportion Successful	# with Unknown Outcome
Red-tailed Hawk	1	1.00	0
Anna's Hummingbird	3	0.67	0
Allen's Hummingbird	5	0.20	0
Downy Woodpecker*	1	1.00	0
Red-shafted Flicker*	2	0.50	0
Black Phoebe	2	1.00	0
Chestnut-backed Chickadee*	2	1.00	0
Bushtit**	5	0.40	0
Pygmy Nuthatch*	2	1.00	0
Swainson's Thrush	3	0.67	0
American Robin	17	0.29	0
Wilson's Warbler	5	0	0
California Towhee	3	0.33	0
Song Sparrow	5	0.60	0
Black-headed Grosbeak	1	0	0
House Finch	3	0	0
American Goldfinch	1	0	0
Total Nests (all species)	61	0.42	0
Total Cavity Nests	7	0.88	0
Total Cup Nests	49	0.35	0
Total Pendulum Nests	5	0.40	0

APPENDIX 2. (continued).

TABLE 3. Number of nests located for each species at **Redwood Creek** in 1998, proportion successful, and number of nests with undetermined outcome. Cavity nesting species are marked with an asterisk*. Pendulum nesting species are marked with two asterisks**. All other species are open cup nesters. Target species are shown in **bold**.

Species	Number of Nests	Proportion Successful	# with Unknown Outcome
Red-tailed Hawk	1	1.00	0
Allen's Hummingbird	5	0.20	0
Belted Kingfisher	1	Unk.	1
Downy Woodpecker*	2	1.00	0
Black Phoebe	3	0.67	0
Warbling Vireo	2	0	0
Steller's Jay	2	0.50	0
Chesnut-backed Chickadee*	4	1.00	1
Bushtit**	4	0	0
Pygmy Nuthatch*	1	Unk.	1
Winter Wren	1	0	0
Swainson's Thrush	13	0.08	0
American Robin	5	0	0
Orange-crowned Warbler	1	1.00	0
Wilson's Warbler	7	0	0
California Towhee	5	0.60	0
Song Sparrow	13	0.62	0
Black-headed Grosbeak	6	0.33	0
Red-winged Blackbird	1	0	0
House Finch	1	0	0
Total Nests (all species)	77	0.33	2
Total Cavity Nests	7	1.00	2
Total Cup Nests	66	0.30	0
Total Pendulum Nests	4	0	0

APPENDIX 2. (continued).

TABLE 4. Number of nests located for each species at Lagunitas Creek in 1998, proportion successful, and number of nests with undetermined outcome. Cavity nesting species are marked with an asterisk*. Pendulum nesting species are marked with two asterisks**. All other species are open cup nesters. Target species are shown in **bold**.

Species	Number of Nests	Proportion Successful	# with Unknown Outcome
Anna's Hummingbird	1	1.00	0
Downy Woodpecker*	3	1.00	0
Hairy Woodpecker*	1	0	0
Western Wood-pewee	4	1.00	0
Pacific-slope Flycatcher	2	0	0
Black Phoebe	2	1.00	0
Warbling Vireo	11	0.10	1
Steller's Jay	1	1.00	0
Tree Swallow*	2	1.00	0
Violet-green Swallow	1	1.00	0
Chesnut-backed Chickadee*	1	1.00	0
Bushtit**	3	0.67	0
Swainson's Thrush	6	0.40	1
American Robin	4	0.75	0
Western Bluebird*	1	0	0
Wilson's Warbler	7	0.14	0
Orange-crowned Warbler	1	1.00	0
California Towhee	1	1.00	0
Song Sparrow	26	0.28	1
Black-headed Grosbeak	8	0.38	0
Brewer's Blackbird	1	0	0
Bullock's Oriole**	1	1.00	0
American Goldfinch	2	0.50	0
Total Nests (all species)	90	0.42	3
Total Cavity Nests	8	0.75	0
Total Cup Nests	78	0.37	3
Total Pendulum Nests	4	0.60	0

APPENDIX 3. Number of territories determined from spot mapping at each site.

TABLE 1. Number of Territories at Lagunitas Creek plot A and B determined from spot mapping data. Target species appear in **bold**.

Plot A		Plot B	
Species	# of Territories	Species	# of Territories
Wood Duck	1	Wood Duck	0
Anna's Hummingbird	0 nests	Anna's Hummingbird	1 nest
Nuttall's Woodpecker	1	Nuttall's Woodpecker	0
Downy Woodpecker	3	Downy Woodpecker	1
Hairy Woodpecker	1	Hairy Woodpecker	2
Western Wood-peewee	4	Western Wood-peewee	1 nest
Pacific-slope Flycatcher	3	Pacific-slope Flycatcher	2
Black Phoebe	2	Black Phoebe	1
Ash-throated Flycatcher	1	Ash-throated Flycatcher	2
Hutton's Vireo	0	Hutton's Vireo	2
Warbling Vireo	6	Warbling Vireo	5-7
Steller's Jay	2	Steller's Jay	3
Western Scrub-jay	1	Western Scrub Jay	1
Tree Swallow	1 nest	Tree Swallow	1 nest
Violet-green Swallow	1 nest	Violet-green Swallow	0
Chestnut-backed Chickadee	3	Chestnut-backed Chickadee	3
Bushtit	1 nest	Bushtit	2
Swainson's Thrush	6	Swainson's Thrush	6-9
American Robin	3-4	American Robin	2
Western Bluebird	0	Western Bluebird	1
Wrentit	4	Wrentit	0
Orange-crowned Warbler	4-5	Orange-crowned Warbler	3
Wilson's Warbler	7-10	Wilson's Warbler	10-11
Spotted Towhee	3	Spotted Towhee	0
California Towhee	3	California Towhee	2
Song Sparrow	18-20	Song Sparrow	22-24
Black-headed Grosbeak	6-7	Black-headed Grosbeak	5-6
Brewer's Blackbird	1 nest	Brewer's Blackbird	Unknown
Bullock's Oriole	1	Bullock's Oriole	0
Purple Finch	2	Purple Finch	0
American Goldfinch	0	American Goldfinch	2 nests

APPENDIX 3. (continued).

TABLE 2. Number of Territories at Redwood Creek plot A and B determined from spot mapping data. Target species appear in **bold**.

Plot A		Plot B	
Species	# of Territories	Species	# of Territories
Red-tailed Hawk	0	Red-tailed Hawk	1
Allen's Hummingbird	3 nests	Allen's Hummingbird	2 nests
Belted Kingfisher	1 nest	Belted Kingfisher	0
Downy Woodpecker	2-3	Downy Woodpecker	1-2
Harry Woodpecker	0	Harry Woodpecker	1
Red-shafted Flicker	1-2	Red-shafted Flicker	1
Olive-sided Flycatcher	0	Olive-sided Flycatcher	1
Pacific-slope Flycatcher	3	Pacific-slope Flycatcher	1
Black Phoebe	0	Black Phoebe	2
Ash-throated Flycatcher	1	Ash-throated Flycatcher	0
Hutton's Vireo	2-3	Hutton's Vireo	1
Warbling Vireo	4	Warbling Vireo	3
Steller's Jay	2	Steller's Jay	1
Western Scrub-jay	2	Western Scrub Jay	3
Chestnut-backed Chickadee	0	Chestnut-backed Chickadee	6-7
Bushtit	0	Bushtit	4-5
Pygmy Nuthatch	0	Pygmy Nuthatch	1
Bewick's Wren	0	Bewick's Wren	1
Winter Wren	2-3	Winter Wren	0
Swainson's Thrush	12-14	Swainson's Thrush	11-12
American Robin	2-3	American Robin	3-4
Wrentit	2-3	Wrentit	1
Orange-crowned Warbler	6	Orange-crowned Warbler	1
Wilson's Warbler	12-13	Wilson's Warbler	10-11
California Towhee	0	California Towhee	5-6
Song Sparrow	16-20	Song Sparrow	20-22
Spotted Towhee	3-4	Spotted Towhee	1
Black-headed Grosbeak	5-6	Black-headed Grosbeak	4
Red-winged Blackbird	0	Red-winged Blackbird	0
Brown-headed Cowbird	Unknown	Brown-headed Cowbird	3
House Finch	0	House Finch	1
American Goldfinch	0	American Goldfinch	1

APPENDIX 3. (continued).

TABLE 3. Number of Territories at **Muir Beach** determined from spot mapping data. Target species appear in **bold**.

Species	Muir Beach # of Territories
Red-tailed Hawk	1
Anna's Hummingbird	3 nests
Allen's Hummingbird	5 nests
Downy Woodpecker	1
Hairy Woodpecker	1
Red-shafted Flicker	2
Pacific-slope Flycatcher	1
Black Phoebe	3
Western Scrub-jay	1
Chestnut-backed Chickadee	5
Bushtit	6
Pygmy Nuthatch	2
Swainson's Thrush	9-10
American Robin	11
Wilson's Warbler	11
California Towhee	4
Song Sparrow	26-29
Black-headed Grosbeak	3
Purple Finch	2
House Finch	6
American Goldfinch	1

APPENDIX 4. Habitat variables used in analyses.

Nest substrate (plant species)

Height of nest

Height of plant that nest is in

Concealment from above	}	estimate made 1 m from nest
Concealment from below		
Side concealment		

Tree species richness

Shrub species richness

Forb species richness

Total shrub cover (all species)

Total forb cover (all species)

Total small trees (all species, 8-23 cm dbh)	}	at an 11.3 m radius from nest. Trees must ≥ 5 m tall with a dbh ≥ 8 cm
Total medium trees (all species, 23-38 cm dbh)		
Total large trees (all species, >38 cm dbh)		
Total stumps (all species)		
Total snags (all species)		
Total number of trees (all species)		

Canopy cover as measured by densiometer (4 readings).

Ground cover (<50 cm) was divided up by % green, grass, shrub, forb, fern, log, leaf litter, bare ground, and water.

Litter depth (taken at 10 locations within 5 m from the nest).

Trees species were divided into 6 categories for analyses; small trees (8-23 cm dbh), medium trees (23-38 cm dbh), large trees (>38 cm dbh), stumps, snags, and total trees. See list below for tree species used in analyses.

Code	Scientific Name	Common Name
ACMA	<i>Acer macrophyllum</i>	Big-leaf Maple
ACNE	<i>Acer Negundo</i>	Box Elder
AECA	<i>Aesculus californica</i>	California Buckeye
ALRU	<i>Alnus rubra</i>	Red Alder
EUGL	<i>Eucalyptus globulus</i>	Blue Gum
FRLA	<i>Fraxinus latifolia</i>	Oregon Ash
PIRA	<i>Pinus radiata</i>	Monterey Pine
QUAG	<i>Quercus agrifolia</i>	Coast Live Oak
SACA	<i>Sambucus callicarpa</i>	Red Elderberry
SALI	<i>Salix species</i>	Willow Species
SESE	<i>Sequoia sempervirens</i>	Redwood
UMCA	<i>Umbellularia californica</i>	California Bay

APPENDIX 4. (continued).

Shrubs species were analyzed by # of stems < 25 cm, # of stems > 25 cm, and total percent cover in a 5 m radius from the nest. See list below for shrub species used in analyses.

Code	Scientific Name	Common Name
ACNE	<i>Acer Negundo</i>	Box Elder/Ash-leaf Maple
AECA	<i>Aesculus californica</i>	California Buckeye
ALRU	<i>Alnus rubra</i>	Red Alder
ARAL	<i>Aralia californica</i>	Elk Clover
BAPI	<i>Baccharis pilularis</i>	Coyote Bush
CETH	<i>Ceanothus thyrsiflores</i>	Blue-blossom
COCO	<i>Corylus coronata</i>	Hazlenut
CORN	<i>Cornus species</i>	Dogwood
FRLA	<i>Fraxinus latifolia</i>	Oregon Ash
LOHI	<i>Lonicera hispidula</i>	Hairy Honeysuckle
LOIN	<i>Lonicera involucrata</i>	Twinberry
LUAR	<i>Lupinus arboreus</i>	Bush Lupine
PHAR	<i>Photinia arbutifolia</i>	Toyon
QUAG	<i>Quercus agrifolia</i>	Coast Live Oak
RHCA	<i>Rhamnus californica</i>	Coffee Berry
RIBE	<i>Ribes species</i>	Gooseberry
ROCA	<i>Rosa californica</i>	California Wild Rose
RUDI	<i>Rubus discolor</i>	Himalayan Blackberry
RUPA	<i>Rubus parviflores</i>	Thimbleberry
RUUR	<i>Rubus ursinus</i>	California Blackberry
SARA	<i>Sambucus racemosa</i>	Red Elderberry
SALI	<i>Salix species</i>	Willow
SYMP	<i>Symphoricarpos species</i>	Snowberry
TODI	<i>Toxicodendron diversilobum</i>	Poison Oak
UMCA	<i>Umbellularia californica</i>	California Bay

APPENDIX 4. (continued).

Forbs species were analyzed by total cover in a 5 m radius from the nest. See list below for forb species used in analyses.

Code	Scientific Name	Common Name
ADOU	<i>Artemisia douglasiana</i>	Mugwort
AFFE	<i>Athyrium filix-femina</i>	Lady fern
ANAR	<i>Anagallis arvensis</i>	Pimpernel
ASCA	<i>Asarum canadense</i>	Wild Ginger
BARR	<i>Brassica rapa</i>	Mustard
CALY	<i>Calystegia species</i>	Morning Glory
CARE	<i>Carex species</i>	Sedge species
CICU	<i>Cicuta species</i>	Water hemlock
COMA	<i>Conium maculatum</i>	Poison Hemlock
CYER	<i>Cyperus eragrostis</i>	Tall cyprus
DISA	<i>Dipsacus sativus</i>	Fuller's Teasel
DOOD	<i>Dolais odorata</i>	Cape Ivy formerly German Ivy
EQUI	<i>Equisetum species</i>	Horsetail
ERCA	<i>Eriodictyon californicum</i>	Yerba Santa
FOVU	<i>Foeniculum vulgare</i>	Sweet Fennel
GAAP	<i>Galium aparine</i>	Bedstraw
GRAS		Grass
HEMA	<i>Heradium maximum</i>	Cow Parsnip
MARA	<i>Marah species</i>	Wild Cucumber
MENT	<i>Mentha species</i>	Mint
MYLA	<i>Myosotis latifolia</i>	Forget-Me-Not
OESA	<i>Oenanthe sarmantosa</i>	Water Parsley
OXOR	<i>Oxalis oregana</i>	Redwood sorrel
PENS	<i>Penstemon species</i>	Penstemon
POAM	<i>Polygonum amphibium</i>	Water smartweed
POAN	<i>Potentilla anserina</i>	Silverweed
POLY	<i>Polygonum species</i>	Knotweed
POMU	<i>Polystichum munitum</i>	Western Swordfern
POPE	<i>Polygonum persicaria</i>	Lady's thumb
PTAQ	<i>Pteridium aquitinum</i>	Brackenfern
RAPH	<i>Raphanus species</i>	Wild Radish
RUME	<i>Rumex species</i>	Dock
RUSA	<i>Rumex salicifolios</i>	Willow Dock
RUSH		Rush species
SADO	<i>Satureja douglassii</i>	Yerba Buena
SCCA	<i>Srophulania californica</i>	Bee Plant
SIOF	<i>Sisymbrium officinale</i>	Hedge Mustard
SOLA	<i>Solanum species</i>	Nightshade
STAC	<i>Stachys species</i>	Hedge Nettle
STEL	<i>Stellaria species</i>	Chicweed
THIS		Unknown Thistle
TRFL	<i>Tradescantia fluminensis</i>	spiderwort
TRIL	<i>Trillium species</i>	Trillium
URTI	<i>Urtica species</i>	Stinging Nettle
VAAQ	<i>Veronica anagallis-aquatica</i>	Water speedwell—Veronica
VERO	<i>Veronica species</i>	Veronica
VICI	<i>Vicia species</i>	Vetch
VIMA	<i>Vinca major</i>	Periwinkle
XAST	<i>Xanthium strumarium</i>	Cocklebur
ZAAE	<i>Zantedeschia aethiopica</i>	Calla Lilly