

Songbird Habitat Associations and Response to Disturbance in the Point
Reyes National Seashore and Golden Gate National Recreation Area

Final report to the Point Reyes National Seashore (cooperative agreement # 1443-CA-8530-95-002
project statement 6) and the Golden Gate National Recreation Area (cooperative agreement # 1443-
CA-8140-96-003) for point count monitoring conducted in the 1998 field season

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Table of Contents

Summary.....	3
Introduction.....	4
Methods.....	5
Point count Census.....	5
Vegetation assessment.....	6
Selection of study sites.....	6
Personnel.....	10
Statistical analysis.....	10
Results and discussion.....	13
Species diversity, richness, and relative abundance by transect.....	13
Species diversity, richness, and relative abundance by habitat / treatment.....	14
Influence of habitat characteristics on secondary population parameters.....	17
Songbird response to grazing in riparian scrub	20
Songbird response to fire in riparian forest.....	21
Songbird response to grazing in mixed grassland-scrub.....	21
Relative abundance of riparian species of conservation priority and concern..	23
Habitat associations for species of concern.....	23
Olive-sided Flycatcher.....	25
Pacific-slope Flycatcher.....	25
Warbling Vireo.....	25
Common Yellowthroat.....	27
Swainson's Thrush.....	28
Wilson's Warbler.....	28
Song Sparrow.....	29
Black-headed Grosbeak.....	30
Relative abundance of nest predator and parasite species	31
Summary and management recommendations.....	33
Acknowledgements.....	34
Literature Cited.....	34
Appendix 1: Survey dates and study site codes.	36
Appendix 2: List of species detected, with total numbers detected by study site.....	38

SUMMARY

In the spring of 1997, the Point Reyes Bird Observatory (PRBO) began a cooperative assessment of songbirds with the Point Reyes National Seashore (PORE) and the Golden Gate National Recreation Area (GOGA), in riparian, coastal scrub and mixed hardwood forest habitats. Riparian monitoring was a continuation of, and elaboration upon, a Brown-headed Cowbird study initiated in 1995 by the Kern River Research Center (KRRC) with PORE and GOGA. Study sites within these major habitat types include those that were actively grazed and burned in the Vision fire of 1995.

Our primary objective was to determine the distribution, relative abundance, and species diversity of songbirds using coastal scrub and riparian habitats of PORE and GOGA. A secondary objective of this project was to investigate habitat affinities and response of these species to fire and ongoing livestock grazing.

In this report we present findings from census data gathered in the 1997 and 1998 breeding seasons. Data gathered in 1998 was used to model habitat associations and evaluate the effects of the Mt. Vision fire on breeding songbirds in riparian forests three years post-burn.

This project has documented the importance of riparian areas on the lands managed by the National Park Service in coastal Marin County. Our results have linked habitat characteristics and specific vegetation structure to bird abundance and diversity. Neotropical migrant species such as Pacific-slope Flycatcher, Warbling Vireo, Wilson's Warbler, and Black-headed Grosbeak, were all more abundant in areas where a greater number of tree species are present. Wider riparian forests with high numbers of tree species, and a variable shrub structure support the most diverse community of breeding birds. Other species such as Song Sparrow and Common Yellowthroat are associated with marshy areas and open forests with a species rich herb understory.

Our results demonstrate that shrub reduction through cattle grazing in coastal scrub results in fewer numbers or complete loss of many shrub associated species such as Wrentit, Orange-crowned Warbler, Bewick's Wren, and Spotted Towhee. Grassland associated species such as Savannah Sparrow respond positively to grazing which may functionally maintain structural characteristics similar to early successional stages.

Future monitoring in these parks should focus on factors that affect avian productivity and, ultimately, the viability of riparian bird species.

BACKGROUND AND INTRODUCTION

In California, riparian areas (i.e., the deciduous trees and shrubs alongside river banks, stream shores, and similar waterways) have been identified as the single most critical habitat for protecting both Neotropical migrant and resident birds (Miller 1951, Gaines 1977, Manley and Davidson 1993). In addition to productive breeding grounds, riparian habitat provides vital over-wintering, migratory stop-over areas (Cogswell 1962, Gaines 1977) and corridors for dispersal (Ralph 1998). This habitat is rapidly disappearing due to development, channelization, water diversion, and grazing. It is not surprising that many threatened and endangered species, and those of special concern, are exclusively or mainly riparian (e.g. Nur et al. 1993).

Coastal scrub habitat in California, particularly coastal sage scrub has been extensively cleared for agriculture and urbanization (Westman 1981). Exotic annuals introduced from the Mediterranean and Middle East during the late 1800's have changed the dynamics of the shrubland communities. It has been demonstrated that coastal scrub has been reduced by grazing and through the invasion of exotic annuals (O'Leary and Westman 1988, O'Leary 1990).

In the spring of 1997, the Point Reyes Bird Observatory (PRBO) began a cooperative assessment of songbirds with the Point Reyes National Seashore (PORE) and the Golden Gate National Recreation Area (GOGA), in riparian, coastal scrub and mixed hardwood forest habitats. Riparian monitoring was a continuation of, and elaboration upon, a Brown-headed Cowbird study initiated in 1995 by the Kern River Research Center (KRRC) with PORE and GOGA. Treatments within these major habitat types include grazed and burned lands.

All monitoring protocols follow nationally standardized guidelines to allow comparisons across space and time. Standardization of methods is essential for land management agencies to garner specific information of population health and status across different regions and habitat types (Ralph et al. 1995).

For the purpose of correlating landbird distribution, abundance, species richness and species diversity with habitat characteristics and treatment type, results from both PORE and GOGA were combined in order to increase samples, and thus to better understand the mechanisms determining distribution and abundance of songbirds in coastal Marin County. Monitoring in addition to point counts was conducted within the Golden Gate National Recreation Area in 1998, the results of which are presented elsewhere (see Gardali et al. 1999).

This report presents findings from point count data gathered in the 1997 and 1998 breeding seasons. Using data gathered in 1998 we model habitat associations and evaluate the effects of the Mt. Vision fire on songbirds in riparian forests during the breeding season, three years post-burn. We also investigate the response of songbirds to ongoing cattle grazing in riparian and scrub habitats of the parks.

The principle objectives of this study may be summarized as follows:

- To determine relative abundance, species richness, and species diversity of landbirds for each transect, habitat, and treatment type within PORE and GOGA.
- To determine the relative abundance and habitat associations of neotropical migrant landbirds of special concern in California, and riparian species of conservation priority at all study locations in both parks.
- To determine the relative abundance of nest parasite and avian nest predator species, by habitat and treatment.
- To make pertinent management recommendations to the Point Reyes National Seashore and the Golden Gate National Recreation Area based on the above data and analysis.

Results of this landbird assessment and subsequent management recommendations to improve habitat for landbirds within PORE and GOGA are presented in this report.

METHODS

Point Count Census

The point count method is used to monitor populations of breeding landbirds. This data also allows us to measure secondary population parameters (abundance, species richness and species diversity; see Data Analysis below), and to make comparisons of bird communities across time, location, habitats and treatments. This enables us to assess variations of bird populations at fixed points, to seek out differences in species composition between habitats.

We followed standard point count protocol, as described in Ralph et al. (1993 and 1995). At each study site one transect was set up containing multiple stations spaced between 200 and 250 m apart. Counts began around local sunrise and continued for no more than four hours in order to restrict the census to peak singing hours. All birds detected within a 5 minute period at each station were recorded, with separate categories for those detected within a radius of 50 m surrounding the census point, those detected greater than 50 m from the point, and those flying over the census area but not observed landing. Only birds detected within the 50 m radius were used in analysis. The type of detection (song, visual, or call) was also noted. Counts were not conducted during excessively rainy, foggy, or windy conditions, where bird activity levels were reduced or the counters' abilities to detect the birds were affected. All transects were censused 3 times each breeding season (with the exception of PORE site, M Ranch, which was established late in the 1997 season and censused only twice that year). Appendix 1 gives the dates of all point count censuses for both years. PRBO field biologists, trained in local bird songs and calls, conducted all censuses.

Vegetation Assessment

The objective of collecting vegetation data at point count stations is to relate the differences in bird species composition and abundance to differences in vegetation. At the end of the 1997 field season, vegetation was assessed at each riparian point count station using the standard relevé method (Ralph et al. 1993). Vegetation characteristics within 50 m of each point were recorded. General characteristics included: percent cover of the plot by each vegetation layer (tree, shrub and herb - herbs consisting of forbs and grasses), width of riparian habitat, slope, aspect (direction of slope) and percent cover of closed canopy, running water, bare ground, litter, and marsh vegetation. Additional information recorded included percent cover of dominant plant species, maximum and minimum heights for each vegetation layer, and the maximum and minimum diameter at breast height (dbh) of trees within 50 m of the point.

Study Sites

All transects located within PORE and GOGA are listed in Tables 1 and 2. A map of the area with locations of transects is presented in Figure 1.

Transects within the Point Reyes National Seashore

During the 1997 and 1998 breeding seasons, a total of 208 point count stations were censused each year within the Point Reyes National Seashore, in both riparian and coastal scrub/grassland habitat. The number of point count census stations at each site and habitat type within PORE is presented in Table 1.

Ninety riparian stations were established in 1995 by the Kern River Research Center, 8 riparian points at Coast Camp were established in 1996 by PRBO, and 8 riparian stations at M Ranch were established by PRBO in 1997. Eleven additional riparian stations in the Arroyo Hondo and Pine Gulch, established prior to 1997 by PRBO, are also included in our analysis. All riparian stations within each transect were established at approximately 200 meter intervals.

Seventy-four point count stations were established in 1997 by PRBO in coastal scrub/grassland habitat within PORE. Two transects of 15 stations each were established in mixed coastal scrub/grassland on Tomales Point, which is grazed by elk, and two transects of 15 stations each were established in mixed coastal scrub/grassland on ranches on the Point Reyes Headlands, which are grazed by cattle. Fourteen stations were established in coastal scrub habitat along the Coast Trail between the Palomarin Trailhead and Bass Lake. Finally, we included 17 coastal scrub stations located on study plots at the Palomarin Field Station, which have been surveyed by PRBO since 1990. All coastal scrub/grassland stations within a transect were established at approximately 250 meter intervals.

Transects within the Golden Gate National Recreation Area

One hundred and thirty-eight point count stations were censused in GOGA in 1997, and 147 stations were censused in 1998. The number of point count census stations within each habitat type at each site in GOGA is presented in Table 2.

The riparian transects (Lagunitas Creek, Redwood Creek, Gerbode Valley, and Tennessee Valley) were established in 1995 by the KRRC and GOGA, and continued to be censused in 1997 and 1998 by PRBO. These transects initially totaled 66 point count stations. In 1998, PRBO added 8 new stations at Redwood Creek to correspond with a new nest monitoring plot also added this year, and added one new station at Tennessee Valley, forming a new total of 75 stations. The remaining 5 study sites (Coyote Ridge, Morse's Gulch, Stinson Gulch, Rodeo/Bobcat Trail, and Stewart Ranch), consisting of 72 stations, were located in coastal scrub, grassland, or mixed hardwood habitats and were established in 1997. These were based on randomly generated survey points for small mammal work conducted by Judd Howell of the Biological Research Division of the US Geological Survey. At each site, one small mammal sampling point served as both a songbird survey station and a starting point for the entire census route.

TABLE 1. Point count transects and treatment types monitored during the 1997 and 1998 breeding seasons within PORE.

STUDY SITE	HABITAT / TREATMENT	# OF STATIONS
	<u>Riparian</u>	
Muddy Hollow	ungrazed/burned 1995	17
Coast Trail/Laguna	ungrazed/burned 1995	13
Coast Camp	ungrazed/burned 1995	8
Upper Olema Creek	predominately cattle-grazed/unburned	13
Abbot's/Kehoe	predominately cattle-grazed/unburned	16
M Ranch ^a	cattle-grazed/unburned	8
Bear Valley	ungrazed/unburned	16
Lower Olema Creek	ungrazed/unburned	15
Arroyo Hondo	ungrazed/unburned	6
Pine Gulch	ungrazed/unburned	5
Total # of riparian stations		117
	<u>Coastal scrub/grassland</u>	
Point Reyes Headlands North	cattle-grazed	15
Point Reyes Headlands South	cattle-grazed	15
Palomarin Grid 5	cattle-grazed	4
Tomales Point North	elk-grazed	15
Tomales Point South	elk-grazed	15
Coast Trail/Palomarin	ungrazed	14
Palomarin Grids	ungrazed	13
Total # of scrub/grassland stations		91
Grand total of PORE stations		208

^aM Ranch was only censused 2 times in 1997

TABLE 2. Point count transects monitored during the 1997 and 1998 breeding seasons, GOGA.

STUDY SITE	HABITAT/ TREATMENT	# OF STATIONS 1997	# OF STATIONS 1998
	<u>Riparian</u>		
Gerbode Valley	ungrazed/unburned	18	18
Tennessee Valley	ungrazed/unburned	13	14
Redwood Creek	ungrazed/unburned	17	25
Lagunitas Creek	ungrazed/unburned	18	18
Total # of riparian stations		66	75
	<u>coastal scrub/grassland</u>		
Rodeo/Bobcat Trail	ungrazed	15	15
Coyote Ridge Trail	ungrazed	15	15
Stinson Gulch	ungrazed	14	14
Total # of scrub/grassland		44	44
	<u>Mixed habitat: grassland, scrub, mixed evergreen</u>		
Morse's Gulch	ungrazed	15	15
Stewart Ranch	ungrazed	13	13
Total mixed habitat		28	28
Grand total of GOGA stations		138	147

FIGURE 1. Map of Marin County showing approximate locations of point count transects.



PORE

1. Tomales Point North
2. Tomales Point South
3. Abbott's / Kehoe (N)
4. Abbott's / Kehoe (S)
5. Point Reyes Headland N
6. Point Reyes Headland S
7. M Ranch
8. Muddy Hollow
9. Coast Trail

PORE (continued)

10. Coast Camp
11. Upper Olema Creek
12. Bear Valley
13. Lower Olema Creek
14. Coast Trail-Palomarin
15. Arroyo Hondo
16. Palomarin Grids 1-4
17. Palomarin, Grid 5
18. Pine Gulch

GOGA

19. Lagunitas Creek
20. Stewart Ranch
21. Morse's Gulch
22. Stinson Gulch
23. Redwood Creek
24. Coyote Ridge Trail
25. Tennessee Valley
26. Rodeo / Bobcat Trail
27. Gerbode

Personnel

In 1998, field work within the Point Reyes National Seashore was primarily conducted by biologists Diana Humple, Aaron Holmes, and Mike Lynes. In 1997, field work within PORE was primarily conducted by Stacy Small, Jim Destaebler, and Katie Fehring. Field work within the Golden Gate National Recreation Area was conducted by Sandy Scoggin, Aaron Crawford, Sue Abbott, and Tom Gardali in 1998, and by Sandy Scoggin, Britt Heidinger, and Tom Gardali in 1997.

All phases of both projects were carried out with the guidance of Terrestrial Program Director Geoffrey Geupel. Data preparation and analysis was performed by Aaron Holmes, Diana Humple, Tom Gardali and Sandy Scoggin, with guidance provided by Dr. Nadav Nur. Computer programs used to manage and summarize data were created by Grant Ballard and Mike Lynes.

Statistical Analysis

We restricted all analyses to species of passerines and near-passerines that are local breeders, excluding migrant or wintering species such as Golden-crowned Sparrows and Fox Sparrows which were often detected during the first visit of the season. Near-passerines included hummingbirds, woodpeckers, and doves. We also eliminated from analysis species which are not properly censused with the point count method, including swallows, swifts, crows, ravens, waterfowl, wading birds, shorebirds, raptors, and owls, regardless of breeding status.

Point count census data yields information on relative abundance, species richness and species diversity. Relative abundance is the mean number of individuals detected per station per visit. In some cases, where specified, we used total number of detections over 3 visits. Species richness is defined as the number of species detected within 50 m. Species diversity measures ecological diversity based on the number of species detected within 50 m weighted by the number of individuals of each species. A high score indicates high ecological (species) diversity. Species diversity was measured using a modification of the Shannon-Wiener index (Krebs 1989).

We examine species richness and diversity in 2 ways. 1) Cumulative richness and diversity are indices calculated across a treatment or transect. Therefore the cumulative species richness for a given habitat would be the total number of species detected within 50 m from all stations within that habitat. 2) The mean richness and diversity indices are calculated using the mean species richness or diversity by station within a habitat type or transect. The mean indices provide a measure of variation and allow for statistical comparisons.

To facilitate meaningful comparisons of species richness, diversity, and relative abundance among habitats, we used specific habitat classifications based on discrete structures and treatment. The two primary riparian habitat classifications are: (1) riparian scrub, with low, thick shrubby willows and/or alders with a very narrow corridor width, and (2) riparian "forest", characterized by larger trees, larger riparian width, and a more

open, forest-like understory (Shuford and Timossi 1989). We classified coastal scrub into 3 types on the basis of shrub cover: (1) coastal scrub, (2) mixed coastal scrub/exotic grassland, and (3) exotic grassland. These habitat types were further classified by grazing treatment: ungrazed, cattle-grazed, or elk-grazed, and for riparian habitat, by whether or not they had recently burned. Each point count station was assigned a habitat and treatment classification. For habitat and treatment analyses we excluded stations that were not easily classified as one of the above habitat types. See Appendix 1, Table 3a, for the number of point count stations at each site that we used in habitat analysis for riparian and mixed hardwood habitats, and Appendix 1, Table 3b, for the number of stations we used at each coastal scrub/grassland transect.

Using data collected during the 1998 season, we calculated the relative abundance at each riparian site of certain species identified to be priority species. These were species that were listed as: (1) neotropical migrant landbirds of special concern in California (Layman 1995), (2) species of management concern (Office of Migratory Bird Management of the United States Fish and Wildlife Service 1995), or (3) riparian associate species of conservation priority (RHJV 1998). Table 3 provides a list of the species included. In order to estimate breeding numbers, we used detections of singing males only. We also calculated the relative abundance by habitat and treatment type of avian nest predators (Western Scrub-Jay, Stellar's Jay, Common Raven, American Crow) and of Brown-headed Cowbird, a nest parasite species.

TABLE 3. Species breeding in riparian habitat within PORE and GOGA which have designated conservation status.

Species of management concern	Neotropical migrants of special concern in California	Species of Conservation Priority in riparian habitat
Olive-sided Flycatcher	Chipping Sparrow	Black-headed Grosbeak
Pacific-slope Flycatcher	SF Common Yellowthroat	SF Common Yellowthroat
Warbling Vireo	Yellow Warbler	Song Sparrow
	Olive-sided Flycatcher	Swainson's Thrush
	Swainson's Thrush	Warbling Vireo
	Warbling Vireo	Yellow Warbler
	Wilson's Warbler	

Statistical tests and models

Differences in abundance, diversity, and species richness between multiple treatments were tested using ANOVA. When significant differences were found we followed with pairwise t-tests. Transformations were used when necessary to meet the assumptions of parametric analysis, and non-parametric tests were used when transformations failed.

For those species of conservation priority in riparian habitat (RHJV 1998) with adequate samples, we used logistic regression to investigate habitat affinities. Logistic regression is used to model the effects of independent variables on a binary response (such as presence or absence) (McCullagh and Nelder 1989). Habitat and vegetation characteristics at stations where a species was detected were compared to those where they did not occur.

To develop multiple variable predictive models we used stepwise multiple regression. Significant terms were entered into a backward stepwise elimination strategy to develop multiple variable models. We used the likelihood ratio statistic to test hypotheses, which is analogous to sums of squares in ANOVA. All models presented here were tested using the Hosmer-Lemeshow goodness of fit χ^2 test ($P > 0.05$).

We used linear regression to model bird species richness, diversity, and abundance, as well as abundance of Song Sparrows in relation to vegetation and habitat characteristics. Multiple regression models were estimated using a backward stepwise elimination procedure. We checked residuals for approximation to normality (Skewness and Kurtosis test for Normality of Residuals) (Stata Corp. 1997). We examined the assumption of homoscedasticity of residuals using the Cook-Weisberg test as described by Stata (Stata Corp. 1997). None of the models presented here showed significant heteroscedasticity (all $P > 0.1$). When tests failed, transformations were used to normalize abundance data.

RESULTS AND DISCUSSION

Species diversity, richness, and relative abundance by transect

A summary for each site of species richness, species diversity, total number of individuals, and mean number of individuals per station by site is presented in Table 4 for 1997 and Table 5 for 1998. We also present mean species richness, mean species diversity, and mean number of individuals per station.

TABLE 4: Species richness by transect, mean species richness at each station, diversity by transect, mean diversity by station, total number of individual detections, mean number of individuals per station per visit, and number of stations by habitat type for all transects in both PORE and GOGA based on 1997 point count data, all detections within 50 m. Includes only species that breed in the area and are well censused by point counts.

Site	Species Richness	Mean Species Richness	Diversity N_1	Mean Diversity	Total indiv.	Relative Abundance	# of Stations
PORE – Ungrazed Riparian							
Bear Valley	40	14	22.6	10.6	643	13.4	16
Lower Olema Creek	43	13.3	21.0	10.2	497	11.0	15
Arroyo Hondo	20	9	13.3	7.8	107	5.9	6
Pine Gulch	17	10.6	11.8	8.9	125	8.3	5
PORE – Primarily Cattle-grazed Riparian							
Upper Olema Creek	39	12.7	23.0	10.2	344	8.8	13
Abbot's/Kehoe	25	10.6	14.0	7.7	554	11.5	16
M Ranch	28	9.6	15.1	7.9	222	13.9	8
PORE – Burned Riparian (1995)							
Muddy Hollow	39	14	17.3	10.4	597	11.7	17
Coast Trail/Laguna	41	13.4	20.6	10.6	434	11.1	13
Coast Camp	18	8	11.2	6.2	186	7.8	8
GOGA – Ungrazed Riparian							
Gerbode Valley	26	9.2	17.4	7.7	322	6.0	18
Tennessee Valley	32	10.7	21.9	8.9	272	7.0	13
Lagunitas Creek	36	11.7	19.6	9.7	410	7.6	18
Redwood Creek	30	8.8	16.6	7.1	332	6.5	17
PORE – Elk-grazed Coastal Scrub/Grassland							
Tomas Point North	17	4	7	3.2	214	4.8	15
Tomas Point South	20	7.4	12.6	6	306	6.8	15
PORE – Cattle-grazed Coastal Scrub/Grassland							
Point Reyes North	10	4.1	4.7	3.3	216	4.8	15
Point Reyes South	15	4.6	5.6	3.0	336	7.5	15
PORE – Cattle-grazed Coastal Scrub							
Palomarin G5	12	6	8.5	5.2	51	4.25	4
PORE – Ungrazed Coastal Scrub							
Palomarin	23	7.3	11.5	6.1	223	5.7	13
Coast Trail/Palo	24	8.7	12.3	7.4	275	6.5	14
GOGA – Ungrazed coastal Scrub/Grassland							
Stinson Gulch	22	4.7	13.2	4.1	139	3.1	14
Coyote Ridge Trail	14	5.8	8.4	4.7	205	4.6	15
Rodeo/Bobcat Trail	17	4.3	10.7	4	104	2.3	15
GOGA – Ungrazed grassland/scrub and mixed hardwood							
Stewart Ranch	28	6.5	21.7	5.8	167	3.7	13
Morse's Gulch	30	7.9	18.4	6.8	233	5.2	15

TABLE 5. Species richness by transect, mean species richness at each station, diversity by transect, mean diversity by station, total number of individual detections, mean number of individuals per station per visit, and number of stations for all transects in both PORE and GOGA based on 1998 point count data, all detections within 50 m. Includes only species that breed in the area and are well censused by point counts.

Site	Species Richness	Mean Species Richness	Diversity N_1	Mean Diversity	Total indiv	Relative Abundance	# of Stations
PORE – Ungrazed Riparian							
Bear Valley	37	10.6	21.5	8.5	401	8.4	16
Lower Olema Creek	27	7.9	13.7	6.7	269	6.0	15
Arroyo Hondo	22	12.1	15.6	10.0	174	9.7	6
Pine Gulch	18	9.4	11.8	7.9	113	7.5	5
PORE – Primarily Cattle-grazed Riparian							
Upper Olema Creek	27	8.8	14.4	7.3	233	6.0	13
Abbot's/Kehoe	21	6.9	10.6	4.9	340	7.1	16
M Ranch	21	8.3	12.2	6.5	179	7.5	8
PORE – Burned Riparian (1995)							
Muddy Hollow	36	12.4	20.4	9.1	518	10.2	17
Coast Trail/Laguna	32	9.6	16.8	8.0	255	6.5	13
Coast Camp	22	9.4	12.6	7.4	171	7.1	8
GOGA - Ungrazed Riparian							
Gerbode Valley	27	10.6	18.3	8.9	404	7.5	18
Tennessee Valley	39	12.4	21.6	9.9	416	9.9	14
Redwood Creek	34	8	16.4	6.7	391	5.2	23
Lagunitas Creek	33	10.4	17.4	8.8	377	7	18
PORE – Elk-grazed Coastal Scrub/Grassland							
Tomales Point North	13	3.2	5.4	2.6	159	3.5	15
Tomales Point South	17	3.8	8.2	3.2	147	3.3	15
PORE – Cattle-grazed Coastal Scrub/Grassland							
Point Reyes North	8	3.3	4.2	2.7	162	3.6	15
Point Reyes South	10	2.3	4.3	1.9	144	3.2	15
PORE – Cattle-grazed Coastal Scrub							
Palomarin G5	20	12	15.8	10.2	98	8.2	4
PORE – Ungrazed Coastal Scrub							
Palomarin	31	12.5	16.5	9.9	471	12.1	13
Coast Trail/Palo	25	9.4	11.8	7.7	393	9.4	14
GOGA - Ungrazed Coastal Scrub/Grassland							
Stinson Gulch	30	7.1	16.4	6.2	197	4.4	14
Coyote Ridge Trail	13	4.6	6.5	4	162	3.6	15
Rodeo/Bobcat Trail	15	4.5	10.6	4.1	145	3.2	15
GOGA - Ungrazed grassland/scrub and mixed hardwood							
Stewart Ranch	31	7.1	23.3	6.1	193	4.3	13
Morse's Gulch	30	8.8	17.4	7.5	262	5.8	15

Appendix 2, Tables 1 and 2 list all species detected within 50 m at each PORE and GOGA study site, respectively, and give the total numbers for each site. These Tables include non-breeders and other species that we have excluded from analyses.

Species diversity, richness, and relative abundance by habitat / treatment

When considering data from the 1998 season, in all habitat types except coastal scrub, the cattle-grazed treatments had lower diversity, species richness, and relative abundance (Table 6). In forested riparian habitats, the cattle-grazed treatment yielded had a species diversity of 15.4, whereas the burned forest and ungrazed forest were higher (20.9 and 21.1 respectively). In riparian scrub, ungrazed areas had a cumulative species diversity of 20.0, compared to 11.9 calculated for the grazed riparian scrub areas. This pattern of reduced diversity in grazed areas also held true in grassland where ungrazed habitat had a species diversity of 12.3 and grazed grassland had a diversity of 7.4. In mixed coastal scrub/grassland habitat, the highest diversity was again found in ungrazed habitat (14.5), and the lowest for cattle-grazed habitat (5.1), with elk-grazed habitat slightly higher (7.7). This pattern did not hold true for 2 coastal scrub transects at Palomarin where the 4 grazed coastal scrub points are adjacent to a narrow riparian corridor and marshy field.

TABLE 6: Species richness, diversity, relative abundance, and number of stations for combined transects in PORE and GOGA, by habitat type. Based on 1998 point count data, all detections within 50 m.

Habitat Type	N	cumulative diversity	Mean Diversity	Species Richness	Mean species richness	Relative Abundance
Riparian						
Burned Forest	38	20.9	8.36	39	10.82	8.3
Cattle-grazed Forest	4	15.4	8.97	22	10.5	7.1
Ungrazed Forest	67	21.1	7.81	50	9.46	6.7
Cattle-grazed Riparian Scrub	17	11.9	5.39	26	7.29	6.8
Ungrazed Riparian Scrub	40	20.0	7.91	39	9.77	7.6
Coastal Scrub/Grassland						
Ungrazed Grassland	5	12.3	3.95	16	4.8	2.7
Cattle-grazed Grassland	7	7.4	2.15	10	2.29	1.2
Ungrazed Scrub/Grassland	42	14.5	4.72	30	5.33	3.8
Elk-grazed Scrub/Grassland	30	7.7	2.92	20	3.5	3.4
Cattle-grazed Scrub/Grassland	30	5.1	2.30	12	2.8	3.4
Ungrazed Coastal Scrub	30	15.6	8.60	35	10.57	10.2
Cattle-grazed Coastal Scrub	4	15.8	10.17	20	12	8.2
Mixed Hardwoods	9	21.6	8.95	31	10.78	6.7

Figure 2 presents mean species diversity by habitat type for 1998, and gives the number of stations associated with each habitat/treatment type for this analysis. Figure 3 presents cumulative species diversity by habitat type. The patterns among habitats were similar between the 2 indices. Overall, the habitat types with the highest cumulative diversity in 1998 were mixed hardwood, ungrazed riparian woodland, burned riparian forest, and ungrazed riparian scrub. Overall, the habitat types with the lowest cumulative and mean diversity indices were cattle-grazed mixed coastal scrub/grassland and cattle-grazed grassland.

FIGURE 2. Mean species diversity per point count station by habitat / treatment type in 1998. Error bars are ± 1 standard deviation.

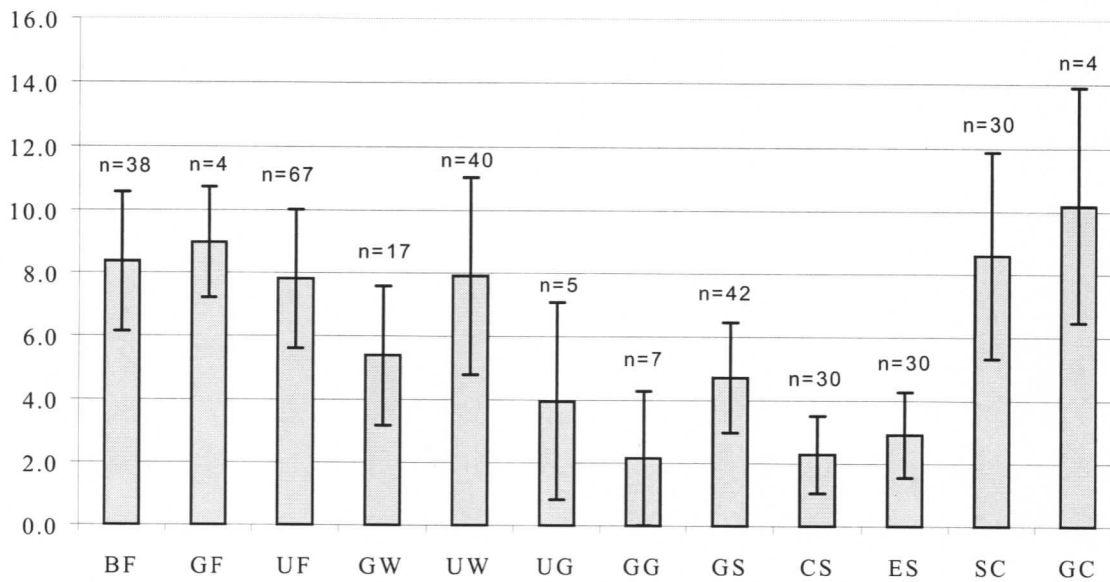
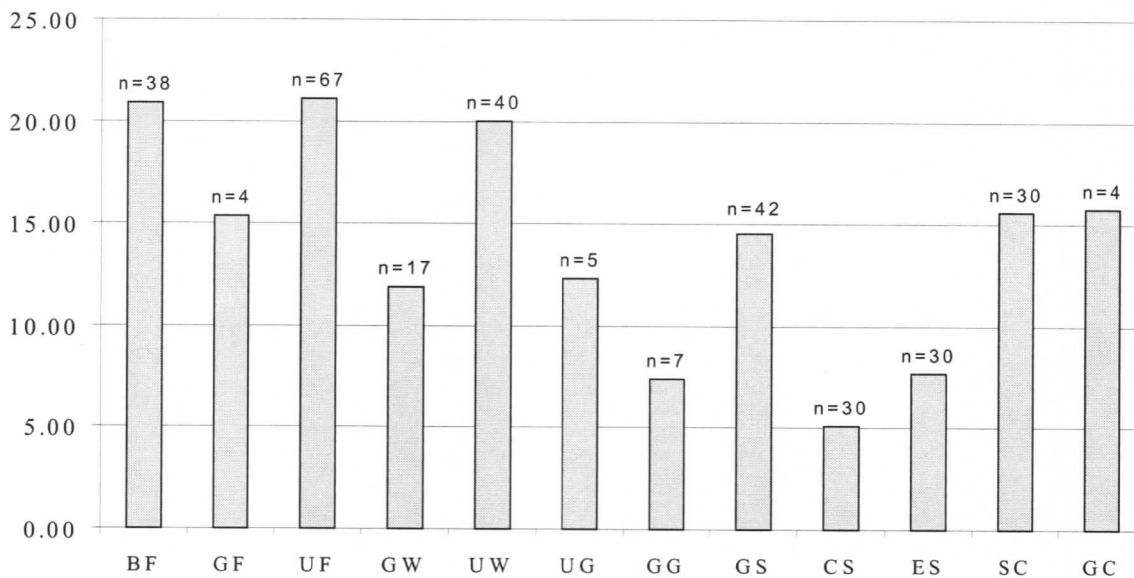


FIGURE 3. Cumulative species diversity by habitat / treatment type in 1998.



Habitat codes used in figures 2 and 3:

BF = burned riparian woodland
 GF = grazed (cattle) riparian woodland
 UF = ungrazed riparian woodland
 GW = grazed (cattle) riparian scrub
 UW = ungrazed riparian scrub
 UG = ungrazed grassland

GG = grazed (cattle) grassland
 GS = ungrazed coastal scrub / grassland
 CS = grazed (cattle) coastal scrub / grassland
 ES = grazed (elk) coastal scrub
 SC = ungrazed coastal scrub
 GC = grazed (cattle) coastal scrub

Influence of habitat characteristics on secondary population parameters

Sixteen habitat characteristics were investigated at riparian sampling stations. These characteristics include herb richness (number of herb - forbs and grasses - species), shrub richness (number of shrub species), tree richness, and an index of shrub height heterogeneity. This index is the height of the smallest shrub "layer" subtracted from the height of the tallest shrubs on the plot. An area with homogenous shrub height would therefore have a low value, and areas with a lot of structural diversity and variable heights would have a higher value. For an explanation of the rest of the habitat variables used in this analysis, see the section on vegetation assessment in the methods. Correlation coefficients of these variables with bird species diversity and richness are presented in Table 7. In order to at least partly reduce the problem of an inflated alpha level (due to multiple statistical tests), we only discuss variables significant at the $P < 0.01$ level, but still present correlation coefficients for variables at the $P < 0.05$ significance level.

TABLE 7. Correlation coefficients (r) and significance of 16 habitat variables as they relate to bird species diversity and richness 166 riparian stations.

Habitat variable	Species Diversity		Species Richness	
	Correlation Coefficient	Significance Level	Correlation Coefficient	Significance Level
Herb richness	--	--	--	--
Shrub richness	--	--	--	--
Tree richness	0.25	***	0.16	*
Herb cover	--	--	--	--
Shrub cover	--	--	--	--
Tree cover	--	--	--	--
Canopy cover	--	--	--	--
High tree height	0.25	***	0.24	**
Maximum tree dbh	0.30	***	0.27	***
Minimum. tree dbh	--	--	0.17	*
Low shrub height	-0.17	*	-0.17	*
High shrub height	0.16	*	0.16	*
Shrub height index	0.24	**	0.24	**
Marsh cover	-0.31	***	-0.17	*
River cover	--	--	--	--
Width of riparian	--	--	--	--

¹ * = $P < 0.05$, ** = $P < 0.01$, *** = $P < 0.001$

Significant positive relationships with bird species diversity were found for maximum tree dbh, maximum tree height, and tree species richness. These remain significant when we control statistically for riparian habitat type (max. tree dbh: $\beta = + 0.026 \pm 0.006$,

$n=164$, $P < 0.001$, tree species richness: $\beta = + 0.40 \pm .121$, $n=166$, $P < 0.001$, maximum tree height: $\beta = + 0.06 \pm 0.06$, $n=165$, $P=0.001$). A significant negative relationship with species diversity was found for marsh cover. This too was significant when we controlled for riparian habitat type ($\beta = - 0.09 \pm 0.023$, $n=166$, $P < 0.001$).

Bird species richness was significantly positively correlated with the maximum tree height and maximum diameter at breast height. As with diversity, these variables remain significant when we control for riparian habitat type (max. tree dbh: $\beta = + 0.028 \pm 0.007$, $n=164$, $P<0.001$).

The negative correlation of bird diversity and species richness with low shrub height and the positive correlation with high shrub height may be interpreted as a positive relationship with diverse structure in the shrub layer. The shrub height heterogeneity index (see above) is significantly correlated with bird diversity, and remains important when we control for riparian habitat type ($\beta = + 0.51 \pm .154$, $n=166$, $P<0.01$).

The influence of the tree species richness, maximum tree dbh, and percent marsh cover were investigated further to determine specific conditions for maximum bird species diversity. Bird diversity increases by 35% as the number of tree species on the plot increases from 0 to 5 or more (Figure 4). Similar results are found for maximum tree dbh (Figure 5). Marsh cover, which is associated with lesser tree cover and fewer tree species, is negatively associated with bird diversity (Figure 6).

These results suggest that older (maximum dbh), taller (height of tree layer), and more diverse forests (high tree species richness), which contain a complex shrub layer structure (heterogeneous height) support the highest bird species diversity in riparian habitat.

Variables which were significant at the $P < 0.05$ level were entered into a stepwise elimination procedure which resulted in multiple variable models for bird species richness and diversity in relation to habitat characteristics. Variables in the final models are all considered simultaneously, accounting for the effects of all other variables in the model. For example, 2 terms such as shrub cover and tree cover may be significantly correlated with diversity or species richness, yet when considered simultaneously one or the other may cease to be important as an explanatory variable. This procedure works well to identify variables which have the most explanatory power in relation to the dependent variable. The 3-variable model for bird species diversity explains some of the variation in bird diversity in riparian habitats of west Marin County (Table 8), and shows that breeding bird diversity is higher in areas with large trees and where there is a shrub layer of variable height. Further, breeding bird diversity is reduced in areas with marsh cover. The final 2 variable model for bird species richness (Table 9) is similar to the diversity model in that bird species richness was also positively correlated with large trees and a variable shrub height. This model was notably different in that marsh cover, when considered simultaneously with the other variables, was not significantly associated with a reduction in the number of species. The observed reduction in species is better predicted by the tree and shrub variables.

FIGURE 4. Tree species richness related to bird species diversity in riparian habitat.

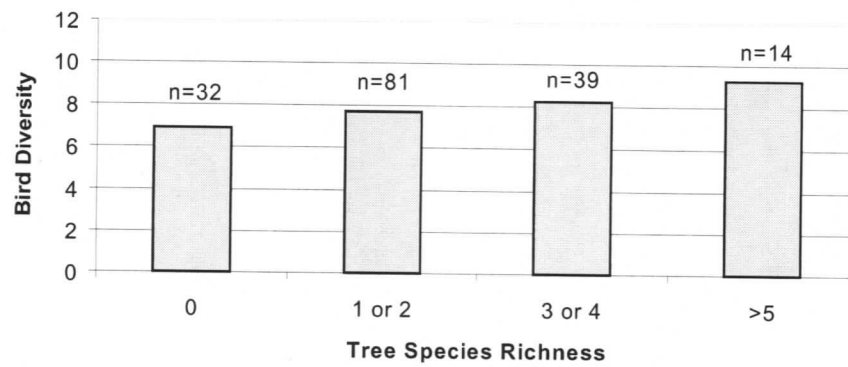


FIGURE 5. Maximum tree diameter at breast height related to bird species diversity in riparian habitat.

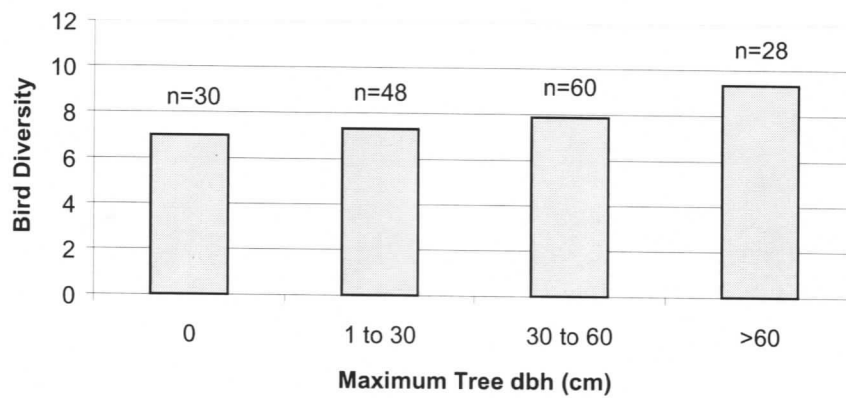


FIGURE 6. Percent of marsh cover related to bird species diversity in riparian habitat.

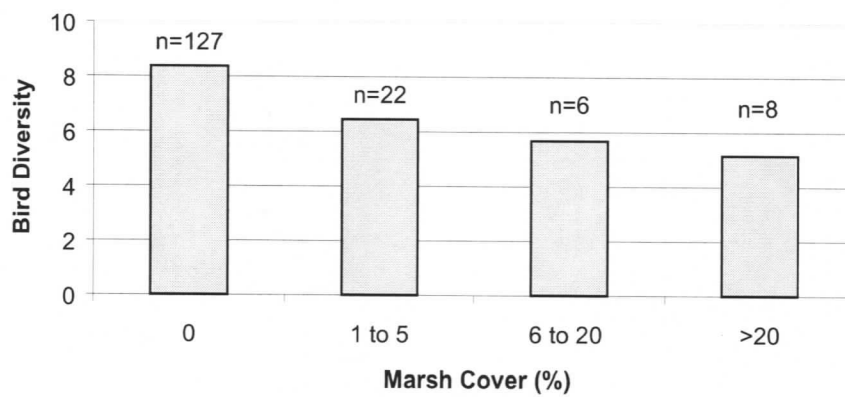


TABLE 8. Linear regression of bird species diversity in relation to marsh cover, shrub height heterogeneity index, and the maximum tree dbh, at 164 riparian sampling stations.

Number of stations = 164		$R^2 = 0.1762$		
F (3, 160) = 11.41		$R^2_a = 0.1608$		
$P > F = 0.0000$				
Dependent term: Bird species diversity				
Term	t	$P > t $	Regression coefficient (β)	SE (β)
Marsh cover	-3.134	0.002	-0.0787	0.0250
Shrub height heterogeneity index	2.416	0.017	0.3667	0.1518
Maximum tree dbh	2.986	0.003	0.0194	0.0065

TABLE 9. Linear regression of bird species richness in relation to the shrub structure index and maximum tree dbh, at 164 riparian sampling stations.

Number of stations = 164		$R^2 = 0.1132$		
F (2, 161) = 10.28		$R^2_a = 0.1022$		
$P > F = 0.0000$				
		Dependent term: Bird species richness		
Term	t	$P > t $	Regression coefficient (β)	SE (β)
Shrub height heterogeneity index	2.61	0.01	0.4726	0.1811
Maximum tree dbh	3.37	0.001	0.0253	0.0075

Songbird response to grazing in riparian scrub habitat

We investigated how bird species richness, diversity, and abundance differed between 17 grazed and 40 ungrazed riparian scrub point count stations. Bird diversity was significantly higher ($t_{57} = 3.01$, $P < 0.01$) at the ungrazed stations. Bird species richness was also significantly higher at the ungrazed stations ($t_{57} = 2.60$, $P < 0.05$). In order to understand what conditions related to grazing might explain these differences, we looked at the effects of habitat variables that were significantly correlated with diversity and richness at these stations (marsh cover, tree cover, shrub cover, tree species richness, and tree height). When we control for the effects of marsh cover, neither bird diversity nor richness differs significantly by grazing treatment (there is significantly more marshy area at the grazed point count stations: $t_{57} = 3.78$, $P < 0.05$). No other variables were able to explain the observed difference. In conclusion, we attribute the difference in bird species diversity and richness at least partially to differing amounts of marsh cover between the treatments. At our study sites marsh cover exists primarily at the edges of riparian habitat.

Songbird response to fire in riparian forest

Bird species richness in riparian forest was significantly higher at stations that were burned in the 1995 Mt. Vision fire ($n=38$) than at the stations ($n=51$) that did not burn (Table 10). Overall abundance of landbirds was also higher at burned stations (Table 10). Once again we attempted to determine what, if any, direct effects of the fire could explain the observed difference. We investigated variables that are significantly correlated with bird species richness (herb cover, high tree height, low tree height, minimum tree dbh, and high shrub layer height) and overall abundance (shrub cover, tree cover, canopy cover, and minimum tree dbh) at these stations. Several of these variables were significantly different between the burned and unburned sites. Although we do not have pre-fire vegetation data, we believe that the observed differences are at least partially attributable to the changes in vegetation structure resulting from the fire. Table 10 presents the mean values for these variables at both the burned and the unburned point count stations. We conclude that the abundance of many shrub-associated species has increased as a result of the fire, while other species associated with high tree cover decreased in abundance.

TABLE 10. Differences in species richness, overall abundance, and 4 habitat variables that differ significantly between burned and unburned riparian forest stations. These variables show a positive correlation with both bird indices, with the exception of tree cover, which shows a negative correlation at these stations.

Variable	Mean Value		ttest (burned vs. unburned)
	Burned stations ($n=38$)	Unburned stations ($n=51$)	
Bird Species Richness	10.8	9.6	$t_{89} = 2.15, P < 0.05$
Bird abundance (3 visits)	24.8	20.5	$t_{89} = 2.42, P < 0.05$
Tree cover (%)	30.3	47.4	$t_{89} = 4.69, P < 0.0001$
Shrub cover (%)	52.5	26.5	$t_{89} = 6.19, P < 0.0001$
Herb cover (%)	42.9	29.2	$t_{89} = 2.93, P < 0.01$
Minimum tree dbh (cm)	14.4	9.7	$t_{89} = 4.60, P < 0.0001$

Songbird response to grazing in mixed grassland-scrub habitat

Bird species diversity and richness differed significantly among the different grazing treatments of mixed grassland-scrub habitat (diversity: $F_2 = 26.8, P < 0.0001, n = 102$, species richness: $F_2 = 19.5, P < 0.0001, n = 102$, ANOVA), with 42 stations located in ungrazed, 30 in elk-grazed, and 30 in cattle-grazed habitat. Both species richness and bird diversity were greatest in the ungrazed habitat, and lowest in the cattle-grazed habitat, with indices from the elk-grazed habitat falling in between. Results from t-tests between these habitat types are presented in Table 11. Vegetation data has not yet been collected at all of these stations, so we are unable to examine these differences in relation to vegetation data. However, field observations reveal that the primary structural difference between these treatments appears to lie in shrub cover, with the ungrazed stations having the most shrub cover, and the cattle-grazed stations having the least.

We looked at distribution (percent of stations) and abundance of dominant landbird species across the treatments in an attempt to explain these dramatic differences. In Table 12 we present the percent of stations at which nine dominant coastal scrub species were

detected in each treatment. A number of species including Bewick's Wren, Wrentit, Spotted Towhee, Western Scrub-Jay, Bushtit, Orange-crowned Warbler were never detected in cattle-grazed habitat but were present at the ungrazed stations. With the exception of Orange-crowned Warbler, which was apparently restricted to areas free from grazing, each of these species was detected on at least some of points in the elk-grazed. Wrentits, Bewick's Wren, and Spotted Towhee were significantly more abundant in the ungrazed than the elk-grazed habitats (Wilcoxin Ranksum test, $P < 0.001$). Although detected at higher percentages of points in the elk-grazed habitat, neither Song Sparrow nor Nuttall's White-crowned Sparrow differed significantly in abundance between treatments. Savannah Sparrows were unusual in that they were most abundant at the cattle-grazed stations. In fact, they were significantly more abundant in each of grazed treatments than in the ungrazed (Wilcoxin Ranksum test, $P < 0.05$), and although not significantly so, were more abundant in the cattle-grazed than elk-grazed treatments (Wilcoxin Ranksum test, $P = 0.056$). These results are not surprising as Savannah Sparrows are primarily a grassland species, and other species such as Wrentit, Bushtit, and Western Scrub-Jay require a dense shrub layer for breeding and cover throughout their life cycle. We believe that these differences in distribution and abundance can be attributed largely to varying degrees of shrub cover. Intensive grazing in this habitat results in open grassy areas, which may be structurally similar to stages of early succession.

TABLE 11. Results of pairwise tests of mean species richness and diversity between ungrazed, elk-grazed, and cattle-grazed study stations in coastal scrub/grassland habitats.

	<u>Significance of difference in species richness</u>
Ungrazed (4.7) vs. Elk-grazed (2.9)	$t_{72} = 4.08$, $P < 0.001$
Ungrazed (4.7) vs. Cattle-grazed (2.3)	$t_{72} = 5.82$, $P < 0.0001$
	<u>Significance of difference in species diversity</u>
Ungrazed (5.3) vs. Elk-grazed (3.5)	$t_{72} = 4.71$, $P < 0.0001$
Ungrazed (5.3) vs. Cattle-grazed (2.8)	$t_{72} = 6.67$, $P < 0.0001$

TABLE 12. Percent of stations at which nine coastal scrub and grassland species were detected in ungrazed, elk-grazed, and cattle-grazed habitats.

<u>Species</u>	<u>Ungrazed</u> n = 42	<u>Elk-grazed</u> n = 30	<u>Cattle-grazed</u> n = 30
Bewick's Wren	38.1	3.3	0
Wrentit	38.1	3.3	0
Song Sparrow	74	80	50
Spotted Towhee	69	13	0
Western Scrub-Jay	21.4	6.7	0
Bushtit	143	3.3	0
Orange-crowned Warbler	16.7	0	0
Savannah Sparrow	42.9	56.7	86.7
Nuttall's White-crowned Sparrow	59.5	66.7	63.3

Relative abundance of riparian species of conservation priority and concern

Relative abundance of singing males for priority species in the riparian drainages of PORE and GOGA are presented in Tables 13 and 14. For site codes see Appendix 1. Chipping Sparrows were only detected at Lagunitas Creek where their relative abundance was low (0.04). Yellow Warblers were only detected with low relative abundance at Upper Olema Creek (0.05) and Redwood Creek (0.01).

TABLE 13. Relative Abundance (mean detections of singing males per point count visit) of riparian species of conservation priority and concern by site, detected within 50 meters, Point Reyes National Seashore, 1998.

SPECIES	Ungrazed				Burned			Predominantly Grazed		
	BV	PI	LO	AH	CT	MH	CC	UO	AK	MR
Olive-sided Flycatcher	0.02	---	---	---	0.05	0.10	0.13	---	---	---
Pacific-Slope Flycatcher	0.38	---	0.16	0.89	0.08	0.24	---	0.08	---	---
Chipping Sparrow	---	---	---	---	---	---	---	---	---	---
Song Sparrow	0.83	0.93	0.80	0.56	0.69	1.02	0.79	1.18	1.27	0.67
Black-headed Grosbeak	0.23	0.20	---	0.11	0.05	0.20	0.17	0.05	---	0.04
Swainson's Thrush	0.33	0.20	0.09	0.28	0.13	0.27	0.08	0.32	0.08	0.21
SF Common Yellowthroat	0.21	---	0.02	---	0.28	0.08	---	0.03	0.17	0.13
Wilson's Warbler	0.48	0.80	0.76	1.11	0.51	0.63	0.38	0.54	0.27	0.46
Yellow Warbler	---	---	---	---	---	---	---	0.05	---	---
Warbling Vireo	0.54	0.13	0.07	0.17	0.18	0.12	---	0.28	---	---

TABLE 14. Relative Abundance (mean detections of singing males per point count visit) of riparian species of conservation priority and concern by site, detected within 50 m, Golden Gate National Recreation Area, 1998.

SPECIES	Ungrazed			
	GERB	TEVA	RECR	LACR
Olive-sided Flycatcher	---	0.07	---	---
Pacific-Slope Flycatcher	---	0.07	0.07	0.15
Chipping Sparrow	---	---	---	0.04
Song Sparrow	0.87	0.83	0.90	0.93
Black-headed Grosbeak	0.07	0.19	0.13	0.35
Swainson's Thrush	0.13	0.05	0.13	0.09
SF Common Yellowthroat	0.26	0.24	---	---
Wilson's Warbler	0.65	0.55	0.45	0.59
Yellow Warbler	---	---	0.01	---
Warbling Vireo	0.02	0.02	0.10	0.43

Habitat associations for riparian species of concern

Data on 16 habitat characteristics were investigated at riparian stations for species of concern using that habitat. Yellow Warblers and Chipping Sparrows were present at too few stations to establish correlates. Correlation coefficients for variables significant at the 0.05 level are presented in Table 15. Herb, shrub, and tree richness refers to the number of plant species which occurred within each respective layer.

TABLE 15. Correlation coefficients and significance level for 8 riparian species of concern relative to 16 habitat variables¹.

Habitat Variable	Olive-sided Flycatcher		Pacific-slope Flycatcher		Warbling Vireo		Common Yellowthroat		Swainson's Thrush		Wilson's Warbler		Song Sparrow		Black-headed Grosbeak	
	r	P > F	r	P > F	r	P > F	r	P > F	r	P > F	r	P > F	r	P > F	r	P > F
Herb richness	--	--	--	--	--	--	0.24	***	--	--	--	--	0.18	*	--	--
Shrub richness	--	--	0.19	*	--	--	--	--	--	--	--	--	--	--	--	--
Tree richness	--	--	0.35	***	0.47	***	-0.24	**	--	--	0.19	*	-0.28	***	0.28	***
Herb cover	--	--	--	--	--	--	0.30	***	--	--	--	--	0.28	***	-0.18	*
Shrub cover	--	--	--	--	-0.18	*	--	--	--	--	--	--	0.19	*	--	--
Tree cover	--	--	0.29	***	0.37	***	--	--	0.17	*	--	--	-0.26	***	--	--
Canopy cover	--	--	0.24	**	0.26	***	-0.27	***	0.16	*	--	--	-0.21	**	--	--
High tree height	0.25	**	0.39	***	0.32	***	-0.16	*	0.18	*	--	--	--	--	0.25	**
Max. tree dbh	--	--	0.31	***	0.34	***	-0.23	**	--	--	--	--	--	--	0.22	**
Min. tree dbh	0.24	**	--	--	--	--	-0.21	**	--	--	0.23	**	--	--	--	--
Low shrub height	--	--	--	--	--	--	--	--	--	--	--	--	0.18	*	-0.16	*
High shrub height	--	--	--	--	0.25	**	--	--	--	--	--	--	--	--	0.16	*
shrub height het.	--	--	--	--	0.29	**	--	--	--	--	--	--	--	--	0.21	**
Marsh cover	--	--	--	--	--	--	0.35	***	-0.16	*	-0.25	**	0.32	**	--	--
River cover	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Width of riparian	--	--	--	--	0.25	**	0.21	**	0.17	*	--	--	--	--	--	--

¹ * = $P < 0.05$, ** = $P < 0.01$, *** = $P < 0.001$

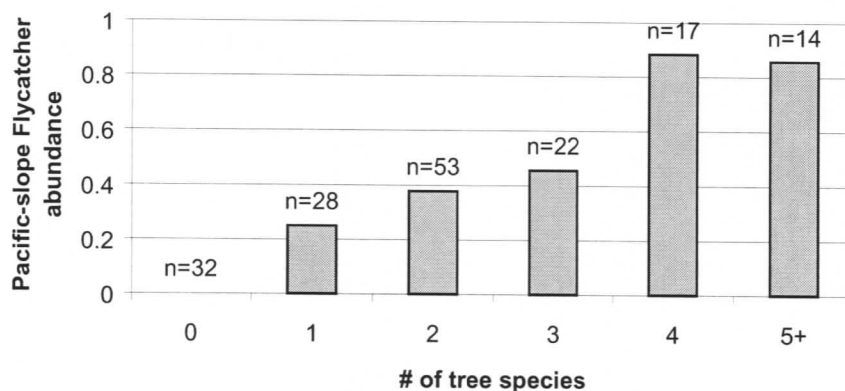
Olive-sided Flycatcher

Relative abundance of Olive-sided Flycatchers was highest at Coast Camp, and they were not detected at many of the other riparian transects. Overall, Olive-sided Flycatchers were detected at only 7% of the riparian stations used to model habitat associations. They are significantly positively correlated with maximum tree height, height of the low trees, and dbh of the smallest trees at a given site. Because they were only detected at 12 stations, we were unable to develop a meaningful predictive model.

Pacific-slope Flycatcher

Pacific-Slope Flycatchers were most abundant in the mixed evergreen forest of the Arroyo Hondo, and were absent from Pine Gulch, Coast Camp, Abbott's/Kehoe, M Ranch, and Gerbode Valley. Overall, Pacific-slope Flycatchers were detected at 25% of the riparian point count stations used in analysis. They were significantly positively associated with tree species richness, tree cover, closed canopy cover, tree height and maximum tree dbh. All of these variables are representative of taller, wider and older riparian forest. Figure 8 shows the mean abundance (total detections) of Pacific-slope Flycatchers related to tree species richness.

FIGURE 8. Tree species richness related to mean Pacific-slope Flycatcher abundance (3 visits)



We entered the 16 variables into a multiple stepwise logistic regression. The resulting model, which correctly predicts occurrence (detected at least once) of Pacific-slope Flycatchers at 79.52% of the stations, is presented in Table 16.

Warbling Vireo

Relative abundance of Warbling Vireos was highest at Bear Valley, and they were not detected at Coast Camp, Abbott's/Kehoe, or M Ranch. The latter two sites are comprised of predominantly low, shrubby willows, which is not suitable habitat for this species, and tree cover at Coast Camp is much reduced as a result of the Mt. Vision fire. Overall, they were detected at 29% of the stations in riparian habitats. Warbling Vireos are significantly positively correlated with tree species richness, tree cover, closed canopy cover, maximum tree height, height of the high shrub layer, and width of the riparian

TABLE 16. Logistic regression model for probability that Pacific-slope Flycatcher will occur at a point count station in riparian habitat.

Number of stations = 166			
LRS (3) = 37.76			
$P > \chi^2 = 0.0000$			
Pseudo $R^2 = 0.2017$			
Dependent term: occurrence of Pacific-slope Flycatcher			
Term	P	Regression coefficient (β)	SE (β)
Tree cover	0.000	0.0408	0.0108
Shrub species richness	0.030	0.2280	0.1061
Tree height	0.013	0.0475	0.0199

corridor. These characteristics are representative of older, taller and wider riparian forest. Warbling Vireos are negatively correlated with shrub cover, which may be simply a function of shrub cover relative to tree cover (these two variables are negatively correlated: $r = -0.38$, $P < 0.0001$, $n=166$). Figure 9 shows mean Warbling Vireo abundance (total detections across 3 visits) related to tree species richness. Figure 10 shows mean riparian corridor width in relation to Warbling Vireo abundance. The mean riparian corridor width was only 52m at 111 stations where vireos did not occur, compared with a mean width of 82m at stations where they were detected at least once ($P = 0.02$, from logistic regression).

We entered significant variables into a backward stepwise elimination and developed a multiple variable logistic regression model that correctly predicts the occurrence of Warbling Vireos at 79.52% of the riparian stations. The final model is presented in table 17. The highly significant correlation with a diverse shrub structure may be indicative of areas where there are gaps within the canopy allowing for patches of taller shrubs within the understory.

FIGURE 9. Tree species richness related to mean Warbling Vireo abundance (3 visits).

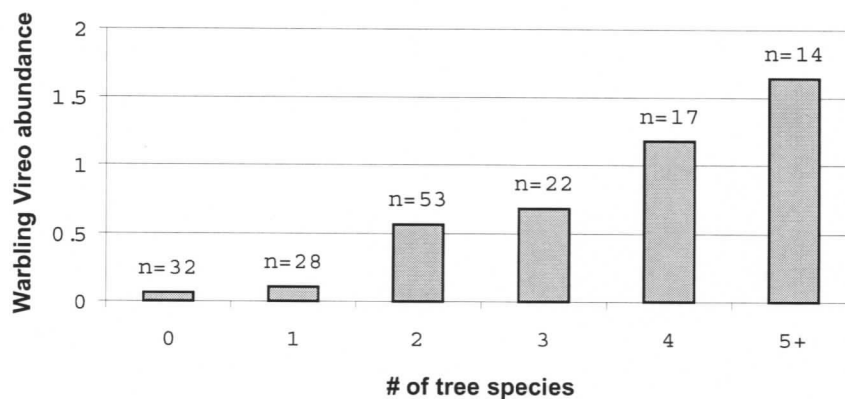


FIGURE 10. Warbling Vireo abundance (3 visits) related to mean riparian corridor width.

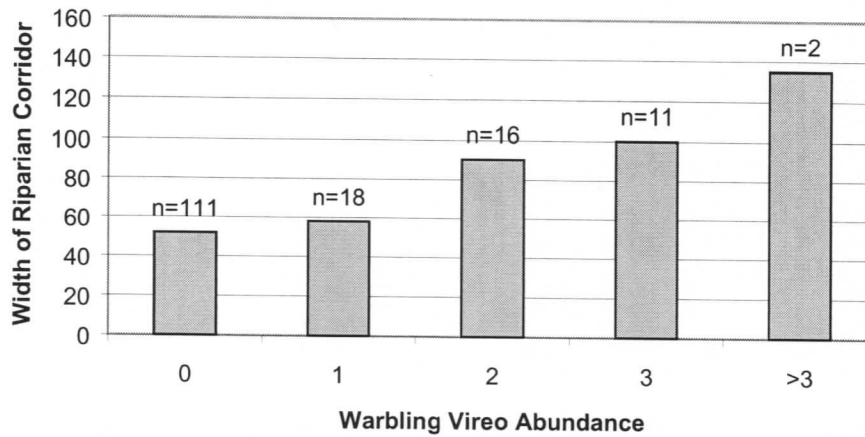


TABLE 17. Logistic regression model for probability that Warbling Vireo will occur at a point count station in riparian habitat.

Number of stations = 166			
LRS (2) = 48.94			
$P > \chi^2 = 0.0000$			
Pseudo $R^2 = 0.2451$			
Dependent term: occurrence of WarblingVireo			
Term	P	Regression coefficient (β)	SE (β)
Tree richness	0.000	0.7048	0.1450
Shrub height heterogeneity index	0.000	0.6061	0.1795

Common Yellowthroat

Common Yellowthroats were most abundant at Coast Trail and were not detected at Pine Gulch, Arroyo Hondo, Coast Camp, Redwood Creek, or Lagunitas Creek. Overall, they were detected at 28% of the 166 riparian stations for which we have vegetation data. Yellowthroats are significantly positively correlated with herb species richness, herb cover, marsh cover, and width of the riparian corridor. They are significantly negatively correlated with a suite of tree variables including tree species richness, canopy cover, tree height, and tree diameter at breast height. We developed a multiple variable logistic regression model that correctly predicts the occurrence of yellowthroats at 79.75% of the riparian stations used in analysis (Table 18).

TABLE 18. Logistic regression model for probability that Common Yellowthroat will occur at a point count

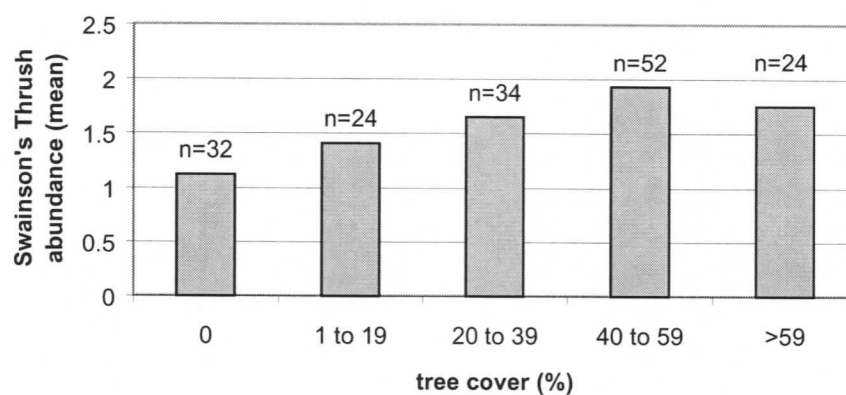
station in riparian habitat.

Number of stations = 158			
LRS (5) = 69.01			
$P > \chi^2 = 0.0000$			
Pseudo $R^2 = 0.3656$			
Dependent term: occurrence of Common Yellowthroat			
Term	P	Regression coefficient (β)	SE (β)
Width of riparian	0.032	0.0066	0.0033
Canopy cover	0.003	-0.0317	0.0130
Marsh cover	0.000	0.1040	0.0359
Tree species richness	0.010	-0.5123	0.2193
Herb cover	0.003	0.0321	0.0116

Swainson's Thrush

Swainson's Thrush was detected on every riparian transect, and were present at 77% of the stations used in habitat association analysis. They are significantly positively correlated with tree and closed canopy cover, tree height, and width of the riparian corridor, again showing affinities to riparian areas with greater amounts of cover and larger width riparian corridors. They are negatively correlated with marsh cover. Figure 11 shows mean Swainson's Thrush abundance in relation to tree cover.

FIGURE 11. Tree cover related to mean Swainson's Thrush detections (3 visits).



Wilson's Warbler

Wilson's Warbler were detected on every riparian transect, and occurred at 87% of the stations used in analysis for habitat association. We found only a few significant correlates for Wilson's Warbler. Abundance was positively correlated with the number

of tree species and the minimum diameter at breast height of trees at a given station. Abundance was negatively correlated with marsh cover.

Song Sparrow

Song Sparrow, the species with the highest relative abundance overall, was most abundant at Abbott's Kehoe and least abundant at M Ranch. Song Sparrows are common throughout riparian habitat in west Marin, and were detected at 96% of the riparian stations used to model habitat associations. Song Sparrows are significantly positively correlated with herb cover, marsh cover, herb richness, shrub cover, and the height of the low shrub layer. They are negatively correlated with tree richness, tree cover, and closed canopy cover. Figures 12 and 13 show Song Sparrow abundance related to tree cover and marsh cover respectively. We developed a multiple regression model of Song Sparrow abundance in relation to tree cover, marsh cover, low height of shrub layer, and herb cover (Table 19).

FIGURE 12. Tree cover related to mean Song Sparrow abundance (3 visits).

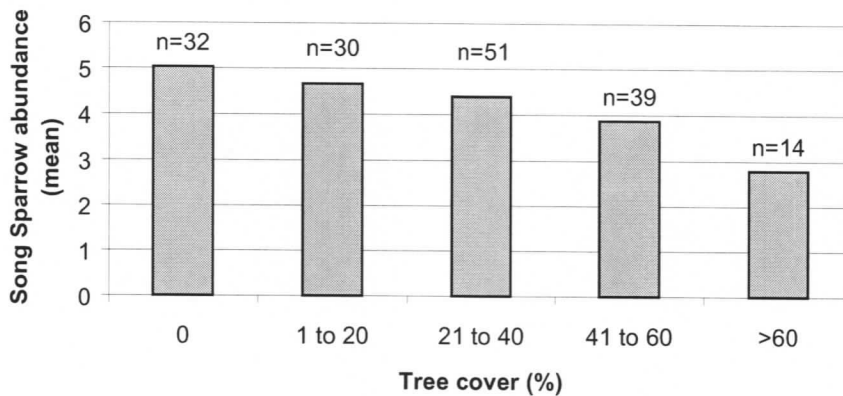


FIGURE 13. Marsh cover related to mean Song Sparrow abundance (3 visits).

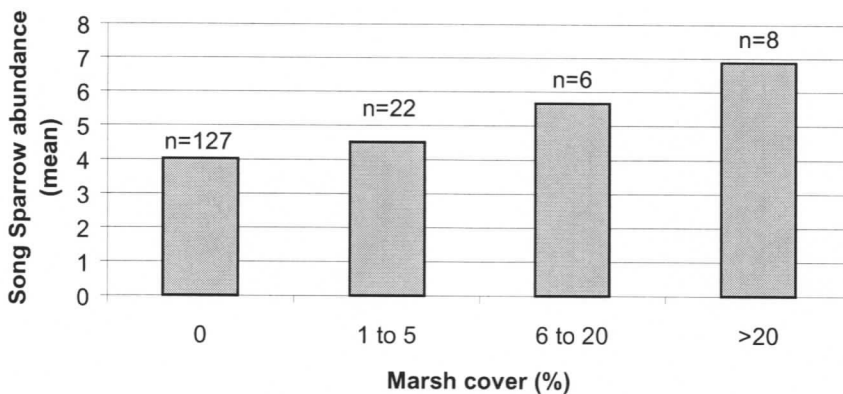


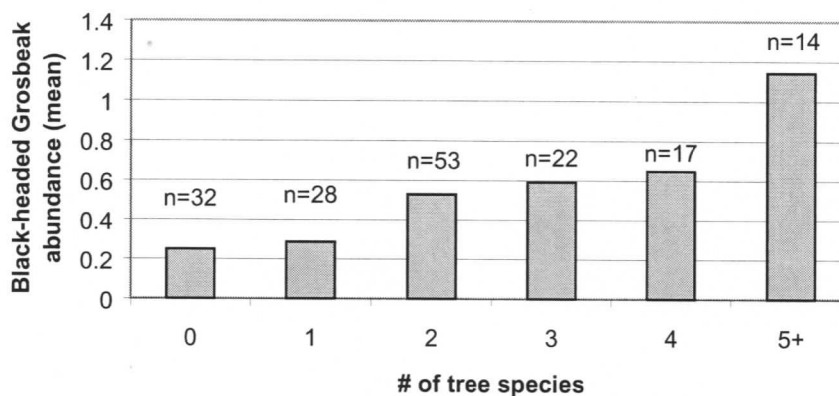
TABLE 19. Linear regression of Song Sparrow abundance in relation to tree cover, marsh cover, height of the low shrub layer, and herb cover at 166 riparian point counts.

Number of stations = 166		$R^2 = 0.2149$		
F (4, 161) = 11.02		$R^2_a = 0.1954$		
$P > F = 0.0000$		Dependent term: Song Sparrow abundance		
Term	T	P	regression coefficient (β)	SE (β)
Tree cover	-2.382	0.018	-0.0181	0.0076
Marsh cover	3.440	0.001	0.0709	0.0206
Height of low shrub layer	2.482	0.014	0.5413	0.2181
Herb cover	3.101	0.002	.0238	.0077

Black-headed Grosbeak:

Black-headed Grosbeaks were most abundant at Lagunitas Creek and were not detected at either Lower Olema Creek or Abbott's/Kehoe, both sites which consist of low riparian scrub. Overall, they were detected at 34% of the stations used in analysis of habitat association. Grosbeaks were significantly positively associated with tree species richness, tree height, and maximum diameter at breast height. Abundance was also positively correlated with the shrub height heterogeneity index. Figure 14 shows Black-headed Grosbeak abundance over 3 visits in relation to tree species richness.

FIGURE 14. Tree species richness related to mean abundance of Black-headed Grosbeak (3 visits).



We entered significant variables into a stepwise elimination strategy and developed the predictive model presented in Table 20. This model correctly classifies occurrence of Black-headed Grosbeak at 69% of the riparian stations used in analysis. This data suggests that grosbeaks are more abundant in riparian habitat with tall trees, high tree richness, and a good structure in the shrub layer (heterogeneous height).

TABLE 20. Logistic regression model for occurrence of Black-headed Grosbeak relative to tree height, and an index of shrub structure (shrub height heterogeneity).

Number of stations = 165			
LRS (2) = 18.51			
P > χ^2 = 0.0000			
Pseudo R ² = 0.0873			
Dependent term: occurrence of Black-headed Grosbeak			
Term	P	Regression coefficient (β)	SE (β)
Tree height	0.000	.0506	.0153
Shrub structure index	0.009	.3574	.1428

The positive association with diverse height in the shrub layer may be indicative of an association with natural openings within the forest where increased light has led to a well developed shrub layer, adjacent to areas with a closed canopy and less well developed shrub layer.

Relative Abundance of Predator and Parasite Species by Habitat and Treatment

We calculated the relative abundance by habitat and treatment types of nest parasite and avian nest predator species detected within 50 m of point count stations for the 1998 field season. Results are presented in Tables 21 and 22.

Nest Parasites

The Brown-headed Cowbird is the only nest parasite species found in this region. The female lays its eggs in the nests of other passerine species, and leaves the host parents with the responsibility of raising it as well as their own young. Often the host species either abandons the nest or is only capable of raising the faster-growing cowbird nestling at the expense of the nestlings of the host species. Examining combined point count data from both parks, Brown-headed Cowbird abundance was highest in grazed riparian scrub (0.29) and burned riparian forest (0.24). Of all other riparian habitats and treatments, cowbirds were least abundant in ungrazed riparian forest (0.14). There was no significant difference in cowbird abundance between burned and unburned riparian forest, or grazed and ungrazed riparian scrub. There was also no significant difference in cowbird abundance between burned and unburned riparian forest, or grazed and ungrazed riparian scrub.

An even lower abundance was shown for cowbirds at the coastal scrub/grassland habitat types and treatments, and they were not detected in some of these habitats. Unlike in the riparian habitat, cowbird abundance varied significantly between grazed and ungrazed coastal scrub-grassland (ungrazed (n=42) vs. cattle-grazed (n=30): $Z = 2.14$, $P < 0.05$, Wilcoxin rank-sum test, ungrazed vs. elk-grazed (n=30): $Z = 2.5$, $P < 0.05$, Wilcoxin rank-sum test). The absence of Brown-headed Cowbirds in cattle-grazed coastal scrub may be a sampling issue due to the low number of stations in this habitat/treatment. Of the

coastal scrub/grassland habitats, cowbirds were most abundant in ungrazed coastal scrub and elk-grazed mixed coastal scrub/grassland.

When examining the factors that influence the presence or absence of cowbirds, one must examine the area from a landscape level (beyond the scope of this project). The presence of nearby livestock feedlots is known to greatly affect the abundance of cowbirds and, consequently, nest parasitism, regardless of whether the site being examined is grazed or not (Goguen 1998).

TABLE 21: Relative abundance (# per visit) of nest parasite and avian predator species in riparian habitat, by habitat type and treatment, averaged over all visits and stations. Based on point count data using all detections within 50 m. Number of stations are presented for each habitat/treatment type (n).

Species	Burned Forest n=38	Grazed Forest n=4	Ungrazed Forest n=78	Grazed Riparian Scrub n=17	Ungrazed Riparian Scrub n=40
Nest Parasite					
Brown-Headed Cowbird	0.24	0.17	0.14	0.29	0.21
Avian Nest Predators					
Steller's Jay	---	0.05	---	---	0.06
Western Scrub-Jay	0.08	0.17	0.05	0.18	0.18

TABLE 22: Relative abundance (# per visit) of nest parasite and avian predator species in coastal scrub, grassland, and mixed coastal scrub/grassland habitats, by habitat type and treatment, averaged over all visits and stations. Based on 1998 fixed-radius point count data at PORE and GOGA, all detections within 50 m. Number of stations are presented for each habitat/treatment type (n).

Species	Grassland		Coastal Scrub		Coastal Scrub/Grassland		
	Not Grazed n=5	Cattle Grazed n=7	Not Grazed n=30	Cattle Grazed n=4	Not Grazed n=42	Elk Grazed n=30	Cattle Grazed n=30
Nest Parasite							
Brown-Headed Cowbird	---	---	0.09	---	0.01	0.10	0.06
Avian Nest Predator							
Steller's Jay	---	---	0.07	---	0.08	---	---
Western Scrub-Jay	---	---	0.56	0.25	0.09	0.06	---

Avian Nest Predators

Where detected, Western Scrub-Jays were most abundant in ungrazed coastal scrub habitat (0.56). They were not detected in true grasslands or in cattle-grazed coastal scrub/grassland, as such habitats generally lack appropriate shrubby substrates or patches. In riparian habitats, Western Scrub-Jays were detected with nearly equal abundance in grazed forest (0.17), grazed riparian scrub (0.18), and ungrazed riparian scrub (0.18). They were least abundant in ungrazed forest and burned forest.

Steller's Jays were detected with relatively low abundance in ungrazed coastal scrub/grassland (0.08), ungrazed coastal scrub (0.07), ungrazed riparian scrub (0.06), and grazed riparian forest (0.05). They were not detected within 50 m of the stations in any other habitat types.

We do not present any data on Common Ravens or American Crows, two other common avian nest predators, because although they were occasionally detected on point counts they are poorly sampled by the point count method. Any data we could present would not accurately reflect their abundance or habitat associations within either park.

SUMMARY AND MANAGEMENT RECOMMENDATIONS

These results demonstrate that various species respond differently to habitat characteristics, and management actions that benefit one species may affect others differently. Riparian habitats in coastal Marin County form a mosaic of structure types from riparian woodland to willow-scrub. Riparian marshes with little tree cover support abundant numbers of Common Yellowthroats and Song Sparrows. Our results also illustrate that the most diverse riparian bird populations are associated with older, taller forests, with high tree species richness, and diverse shrub structure.

Both Warbling Vireo and Common Yellowthroat abundance were positively correlated with the width of the riparian corridor. We recommend managing for increased width of riparian corridors in riparian forest habitats.

The presence of the full range of early to late successional stage riparian woodland has been identified as key feature for the successful management of riparian bird communities (RHJV 1998). Data collected in GOGA (Gardali et al. 1999) supports this statement. For example, Warbling Vireos established territories in areas with large trees, but have higher nesting success when nest placement is lower in smaller trees. Gardali et al. also found that small red alder trees are important for both Song Sparrow and Swainson's Thrush nest success, which further supports the above statement. Warbling Vireo, Pacific-slope Flycatcher, Wilson's Warbler, and Black-headed Grosbeak are all positively associated with tree species richness, or with other conditions such as a wide corridor that may be indicated by high tree species richness. We recommend management that will promote system-wide high structural diversity, as well as high floristic diversity. We further recommend the elimination, reduction, or management (fencing of riparian) of grazing in spring and during the breeding season (February through July) to maximize the understory habitat value to landbirds and minimize foraging habitat for cowbirds (RHJV 1998).

These results also indicate that cattle grazing in scrub-grassland can result in the reduction or loss of many shrub associated species (such as Wrentit, Orange-crowned Warbler, Bewick's Wren, Spotted Towhee) from grazed areas. Grassland species such as Savannah Sparrow respond positively to grazing in this habitat, occurring at twice as many stations in areas being grazed by livestock. Shrub nesting birds would benefit from reduction or removal of livestock in this habitat, which would allow for recruitment of shrubs. When not in conflict with other management concerns such as exotic weed control, we recommend implementing a rest-rotation grazing plan with extensive rest periods to allow for shrub growth.

In cooperation with PORE and GOGA, PRBO has gathered extensive information about the distribution of landbirds in these habitats, and an inventory of other habitats is planned for 1999 and 2000. While knowledge of distribution, abundance, and habitat associations are important to management, abundance can be misleading as an indicator of habitat quality (Van Horn 1983). More information is needed on how common treatments such as livestock grazing and burning influence primary population parameters (productivity and survival), and future research and monitoring on publicly owned land in West Marin should be directed at addressing these important questions.

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APPENDIX 1

TABLE 1a. Dates of point count visits, Point Reyes National Seashore 1997.

BV	UO	LO	AK	CT	MH	PI	AH	CC	MR
5/3	4/29	5/3	5/6	4/28	4/28	5/31	5/6	5/5	--
5/28	5/28	6/1	5/30	5/27	5/27	6/12	5/31	6/10	6/25
6/24	6/24	6/27	6/27	6/23	6/23	6/26	6/26	7/3	7/3
TN	TS	PN	PS	CP	PG	G5			
5/16	5/13	5/19	5/20	5/2	5/5	5/6			
6/3	6/3	6/2	6/2	5/30	5/30	5/31			
7/2	6/28	7/1	7/1	7/7	6/26	6/26			

TABLE 1b. Dates of point count visits, Point Reyes National Seashore 1998.

BV	UO	LO	AK	CT	MH	PI	AH	CC	MR
5/16	4/28	4/28	4/29	5/7	4/27	5/13	5/13	5/15	5/11
6/2	6/1	6/5	6/3	5/26	5/30	6/5	6/9	6/3	6/11
6/25	6/25	6/26	6/29	6/29	6/25	6/23	7/2	6/30	7/1
TN	TS	PN	PS	CP	PG	G5			
5/15	5/11	5/13	5/14	4/22	5/13	5/16			
6/5	6/3	6/2	6/2	6/10	6/9	6/12			
7/3	6/24	6/28	6/28	7/8	7/1	7/3			

Study Site Codes:

AH = Arroyo Hondo

AK=Abbott's/Kehoe

BV = Bear Valley

CC = Coast Camp

CP = Coast Trail, Palomarin

CT = Coast Trail

G5 = Palomarin, Grid 5

LO = Lower Olema

MH = Muddy Hollow

MR = M Ranch

PG = Palomarin Grids

PI = Pine Gulch

PN = Point Reyes Headlands North

PS = Point Reyes Headlands South

TN = Tomales Point North

TS = Tomales Point South

UO = Upper Olema

TABLE 2a Dates of Point Count Visits, Golden Gate National Recreation Area, 1997.

CRTR	GERB	LACR	MOGU	RECR	RODE	STRA	STGU	TEVA
5/13	5/5	4/28	5/13	4/29	5/6	5/6	5/5	4/28
6/2	5/31	5/20	5/30	5/23	5/20	6/1	5/30	5/30
6/24	6/18	6/18	6/22	6/10	6/18	6/19	6/15	6/17

TABLE 2b. Dates of Point Count Visits, Golden Gate National Recreation Area, 1998.

CRTR	GERB	LACR	MOGU	RECR	RODE	STRA	STGU	TEVA
5/14	5/13	4/25	5/20	4/23	5/14	5/9	5/12	4/24
6/8	5/21	5/21	6/1	5/26	6/6	6/6	6/4	5/20
7/2	6/20	6/18	6/30	6/17	6/27	6/25	6/24	6/17

Study Site Codes

CRTR=Coyote Ridge Trail

GERB=Gerbode

LACR=Lagunitas Creek

MOGU = Morse's Gulch

RECR = Redwood Creek

RODE = Rodeo/Bobcat Trail

STRA = Stewart Ranch

STGU = Stinson Gulch

TEVA = Tennessee Valley

APPENDIX 1.

TABLE 3a. The number of point count census stations at each location used in habitat analysis for riparian and mixed hardwood.

Site	Burned Riparian Forest	Ungrazed Riparian Forest	Grazed Riparian Forest	Ungrazed Riparian Scrub	Grazed Riparian Scrub	Mixed Hardwood
PORE						
Muddy Hollow	17					
Coast Trail/Laguna	13					
Coast Camp	8					
Upper Olema Creek		3	4	3	3	
Abbot's/Kehoe				2	14	
Bear Valley		16				
Lower Olema Creek				6		
Pine Gulch		5				
GOGA						
Gerbode Valley				18		
Tennessee Valley				11		
Redwood Creek		25				
Lagunitas Creek		18				
Stewart Ranch						6
Morse's Gulch						3

TABLE 3b. The number of point count census stations at each location used in habitat analysis for coastal scrub/grassland habitat.

Site	Cattle-grazed Coastal Scrub/ Grassland	Elk-grazed Coastal Scrub/ Grassland	Ungrazed Coastal Scrub/ Grassland	Cattle Grazed Coastal Scrub	Ungrazed Coastal Scrub	Cattle- grazed Grassland	Ungrazed Grassland
PORE							
Point Reyes	15						
Headlands North							
Point Reyes	15						
Headlands South							
Tomas Point North		15					
Tomas Point South		15					
Palomarin Grid 5				4			
Palomarin Grids					13		
Coast Trail/Palo					14		
GOGA							
Morse's Gulch			3		3		
Coyote Ridge Trail			15				
Stinson Gulch			9				5
Stewart Ranch						7	
Rodeo/Bobcat Trail			15				

APPENDIX 2

TABLE 1. Summary of all species, including non-breeders, detected within 50 m of all stations by site, Point Reyes National Seashore, 1998.

SPECIES	AH	AK	BV	CC	CP	CT	G5	LO	MH	MR	PG	PI	PN	PS	TN	TS	UO
Green Heron	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Double-crested Cormorant	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Mallard	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Virginia Rail	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
American Coot	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Whimbrel	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Killdeer	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
California Quail	5	6	26	3	18	1	7	5	48	0	8	0	0	0	0	3	6
Band-tailed Pigeon	0	0	2	0	2	0	0	0	52	0	0	0	0	0	0	0	0
Mourning Dove	0	0	0	1	0	0	0	0	5	2	1	0	0	0	0	0	1
Rock Dove	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Turkey Vulture	0	0	4	0	2	0	0	0	0	0	0	0	0	0	0	0	14
Northern Harrier	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sharp-shinned Hawk	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Red-tailed Hawk	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	1
Red-shouldered Hawk	0	0	2	0	0	0	0	1	0	0	0	0	0	0	0	0	2
Great Horned Owl	0	0	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0
Hairy Woodpecker	0	0	1	1	0	0	0	0	3	0	0	0	0	0	0	0	0
Downy Woodpecker	1	0	4	0	0	4	1	4	10	0	0	1	0	0	0	0	0
Nuttall's Woodpecker	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Acorn Woodpecker	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Red-shafted Flicker	3	0	0	0	3	5	0	1	7	0	5	0	0	0	0	0	0
Anna's Hummingbird	0	2	2	1	2	1	0	3	5	0	8	5	0	0	0	0	3
Allen's Hummingbird	6	1	23	11	3	18	1	38	23	2	23	3	0	0	1	1	8
Ash-throated Flycatcher	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	4
Black Phoebe	0	3	1	0	0	0	0	2	5	0	0	0	0	0	0	0	1
Olive-sided Flycatcher	0	0	1	3	0	2	0	0	7	0	0	0	0	0	0	0	0
Western Wood-pewee	0	0	6	0	0	2	0	0	10	0	0	0	0	1	0	0	4
Pacific Slope Flycatcher	25	0	18	0	7	8	0	8	13	0	5	3	0	0	0	0	3
Horned Lark	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0
Steller's Jay	13	0	2	2	0	2	0	6	4	1	6	0	0	0	0	0	0
Wester Scrub-Jay	0	9	8	2	24	3	3	5	4	8	29	0	0	0	3	2	3
American Crow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
European Starling	0	9	0	0	9	1	0	0	7	3	0	0	0	0	3	0	0
Brown-headed Cowbird	0	13	8	7	1	0	0	4	20	0	7	3	4	1	0	9	10
Red-winged Blackbird	0	42	27	0	0	0	0	23	1	39	0	0	1	9	0	11	1
Brewer's Blackbird	0	47	5	10	0	4	4	0	1	7	0	0	0	8	0	0	0
Purple Finch	4	2	2	1	4	1	3	2	2	1	15	0	0	0	0	0	4
House Finch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	2	0
American Goldfinch	0	8	3	9	8	12	8	1	12	5	1	13	10	2	8	6	0
Pine Siskin	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0
Savannah Sparrow	0	1	0	0	0	0	2	0	0	0	0	0	38	84	69	13	1
Nuttall's White-crowned Sparrow	0	13	0	1	45	0	14	0	1	3	23	0	54	18	23	31	0
Golden-crowned Sparrow	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	3
Oregon Junco	5	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
Rufous-crowned Sparrow	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Song Sparrow	11	108	57	48	74	57	10	55	96	33	61	26	53	11	37	51	58
Spotted Towhee	3	0	2	10	59	2	8	3	5	0	62	0	0	0	2	5	1
California Towhee	0	0	5	2	4	5	2	3	6	0	2	0	0	0	0	0	10
Black-headed Grosbeak	2	0	15	5	0	2	0	0	14	1	3	4	0	0	0	0	3
Lazuli Bunting	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Cliff Swallow	0	4	17	0	0	0	1	3	0	0	0	0	0	0	0	0	8
Barn Swallow	0	3	0	0	0	0	0	2	7	2	0	0	0	10	0	0	1
Tree Swallow	0	0	15	2	0	0	0	2	7	0	0	0	0	0	0	0	7
Violet-green Swallow	0	0	7	0	0	0	0	2	0	0	0	0	0	0	0	0	1

APPENDIX 2.

TABLE 1. continued

SPECIES	AH	AK	BV	CC	CP	CT	G5	LO	MH	MR	PG	PI	PN	PS	TN	TS	UO
Northern Rough-winged Swallow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Cedar Waxwing	0	0	0	0	0	4	0	0	0	32	0	0	0	0	0	0	0
Warbling Vireo	3	0	27	0	0	7	0	4	7	0	0	3	0	0	0	0	14
Hutton's Vireo	0	0	1	0	0	3	0	0	4	0	3	0	0	0	0	0	0
Yellow-rumped Warbler	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Orange-crowned Warbler	6	1	3	13	12	12	3	0	18	7	10	3	0	0	0	0	0
Yellow Warbler	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Common Yellowthroat	0	17	33	0	0	22	0	3	8	4	0	4	0	0	0	1	1
Wilson's Warbler	23	17	28	18	18	33	6	43	44	21	14	15	1	0	3	5	27
House Sparrow	0	0	6	0	0	0	0	2	0	0	0	0	0	5	0	0	0
Bewick's Wren	2	4	4	9	36	7	5	0	16	3	43	0	0	0	1	0	6
Winter Wren	16	0	0	0	0	3	0	3	3	1	3	0	0	0	0	0	0
Marsh Wren	0	11	8	0	0	1	0	0	0	4	0	1	0	0	0	3	0
Red-breasted Nuthatch	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Oak Titmouse	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chestnut-backed Chickadee	14	0	18	0	6	8	2	13	10	11	19	1	0	0	0	0	16
Wrentit	4	8	5	3	69	1	6	11	0	8	77	12	0	0	0	1	16
Bushtit	1	0	7	0	8	3	9	2	3	0	8	5	0	0	1	0	2
Golden-crowned Kinglet	4	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0
Swainson's Thrush	17	18	31	11	6	15	3	21	32	15	15	10	1	0	1	2	24
American Robin	6	0	3	0	0	9	0	3	12	0	11	1	0	0	0	0	3
Western Bluebird	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	1	0

APPENDIX 2

TABLE 2. Summary of all species, including non-breeders, detected within 50 m of all stations by site, Golden Gate National Recreation Area, 1998.

SPECIES	CRTR	GERB	LACR	MOGU	RECR	RODE	STGU	STRA	TEVA
Green Heron	0	0	0	0	1	0	0	0	0
Mallard	0	0	0	0	8	0	0	0	0
Virginia Rail	0	1	0	0	0	0	0	0	1
California Quail	8	7	0	2	5	12	2	16	4
Band-tailed Pigeon	0	0	0	0	0	0	1	0	0
Mourning Dove	0	7	1	0	7	0	0	1	4
Turkey Vulture	0	0	0	0	0	2	2	0	0
Red-tailed Hawk	0	0	0	1	0	0	0	0	0
Great Horned Owl	0	0	0	0	0	0	0	0	1
Hairy Woodpecker	0	0	3	0	3	0	0	0	4
Downy Woodpecker	0	0	0	0	3	0	1	0	2
Red-shafted Flicker	0	1	0	3	3	0	2	0	3
Vaux's Swift	0	0	0	2	0	0	0	0	0
Anna's Hummingbird	0	1	3	6	10	5	3	0	8
Allen's Hummingbird	0	26	10	15	14	0	1	6	13
Ash-throated Flycatcher	0	3	2	0	0	0	0	2	0
Black Phoebe	0	0	0	0	0	0	0	0	1
Olive-sided Flycatcher	0	0	0	0	0	0	0	0	4
Western Wood-pewee	0	0	5	1	1	0	0	4	2
Pacific Slope Flycatcher	0	0	10	7	6	0	0	13	5
Willow Flycatcher	0	0	0	0	0	0	0	0	1
Hammond's Flycatcher	0	0	0	0	0	0	0	0	1
Horned Lark	0	0	0	0	0	0	0	1	0
Steller's Jay	0	0	4	4	6	0	12	7	10
Wester Scrub-Jay	1	9	2	7	3	4	4	7	9
Common Raven	2	0	0	0	2	3	0	0	0
American Crow	0	0	1	0	0	0	0	4	0
European Starling	0	0	2	0	2	0	0	0	4
Brown-headed Cowbird	0	13	12	0	8	0	1	0	6
Red-winged Blackbird	0	33	4	1	12	6	0	0	93
Brewer's Blackbird	0	9	1	1	5	0	0	0	0
Purple Finch	0	0	4	10	3	0	6	2	2
House Finch	0	3	0	0	0	0	0	0	5
American Goldfinch	4	16	6	1	6	3	1	1	11
Lesser Goldfinch	7	0	1	0	0	0	0	0	0
Pine Siskin	0	0	0	1	0	0	5	3	0
Savannah Sparrow	20	0	0	0	0	15	0	8	0
Grasshopper Sparrow	0	0	1	0	0	1	0	1	0
Lark Sparrow	0	0	1	0	0	0	1	3	0
Nuttall's White-crown Sparrow	38	0	0	0	1	23	0	0	0
Chipping Sparrow	0	0	2	0	0	0	0	12	0
Oregon Junco	0	0	0	5	0	0	4	15	2
Rufous-crowned Sparrow	0	0	0	1	0	0	0	0	0
Song Sparrow	57	65	69	14	87	22	12	0	44
Spotted Towhee	17	12	8	54	5	25	36	11	14
California Towhee	0	8	4	9	5	2	11	5	11
Black-headed Grosbeak	0	8	28	0	11	0	1	0	10
Lazuli Bunting	2	0	0	0	0	0	0	4	0
Cliff Swallow	0	0	6	0	0	0	0	0	0
Barn Swallow	0	0	1	0	4	0	0	0	0
Tree Swallow	0	0	9	0	8	0	0	0	2
Violet-green Swallow	0	0	0	1	13	0	0	0	0
Warbling Vireo	0	1	32	0	9	0	1	14	3
Hutton's Vireo	0	0	0	7	1	0	1	2	0
Orange-crowned Warbler	0	8	6	13	7	0	12	4	12
Yellow Warbler	0	0	0	0	1	0	0	0	1
Black-throated Gray Warbler	0	0	0	0	0	0	0	1	0
Mac Gillivray's Warbler	0	1	0	0	1	0	0	0	2

APPENDIX 2.

TABLE 2. continued

	CRTR	GERB	LACR	MOGU	RECR	RODE	STGU	STRA	TEVA
<u>SPECIES</u>									
Common Yellowthroat	1	18	0	0	0	0	0	0	13
Wilson's Warbler	1	38	38	13	50	2	9	12	31
Bewick's Wren	4	14	9	16	2	14	26	0	14
Winter Wren	0	0	0	0	7	0	0	6	1
Marsh Wren	0	0	0	0	0	0	0	0	7
Brown Creeper	0	0	1	2	0	0	0	0	3
Chestnut-backed Chickadee	0	25	35	18	30	0	10	14	17
Wrentit	2	26	9	20	0	9	21	5	8
Bushtit	0	18	19	23	6	2	8	8	9
Golden-crowned Kinglet	0	0	0	5	0	0	0	0	0
Swainson's Thrush	0	28	36	1	56	0	2	0	9
Hermit Thrush	0	0	0	0	0	0	1	0	0
American Robin	0	6	9	1	15	0	1	2	15
Western Bluebird	0	0	0	1	0	0	1	3	0