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Landbirds in the Marin Municipal Water District:

An examination of population change from 1996 to 2004

A PRBO Conservation Science Report to the Marin Municipal Water District

Black-throated Gray Warbler (*Dendroica nigrescens*)

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EXECUTIVE SUMMARY

Point count surveys in the lands managed by the Marin Municipal Water District (MMWD) were established by PRBO Conservation Science (formerly the Point Reyes Bird Observatory; PRBO) during the breeding season of 1996, and were repeated in 1997 and 1998. In 2001 and again in 2004, PRBO resurveyed these point counts as part of a long-term landbird monitoring program, with the intention of repeating these surveys every third year. The primary goal of the monitoring plan is to estimate population trends of songbirds on lands owned and managed by MMWD. Long-term monitoring is an important tool in songbird conservation as it provides a wealth of useful information about bird populations (CPIF 2000). The purpose of this report is to look for changes in songbird population sizes from 1996 to 2004.

A total of 327 sampling points, distributed throughout the habitats and geographic extent of the area, were surveyed each year. The most common landbird species across all years, in order of abundance starting with most abundant, were Pacific-slope Flycatcher, Chestnut-backed Chickadee, Spotted Towhee, Oregon Junco, Warbling Vireo, Bewick's Wren, Wrentit, Bushtit, Wilson's Warbler, Orange-crowned Warbler, Anna's Hummingbird, Western Scrub-Jay, Steller's Jay, and Black-throated Gray Warbler.

We used linear and curvilinear regression to estimate population trends from data spanning an eight-year time period of which only five years were sampled (1996, 1997, 1998, 2001, 2004). Each species had five data points (i.e., years) as abundance data from all sites were combined for these analyses.

Although we have a very adequate sample size of point count stations (327) for detecting trends, what we lack, to date, appears to be an adequate number of sampling of years; the 95% Confidence Intervals for 52 of the 53 species examined contained zero. Hence, in the relatively few cases where statistical significance was found, we could not confidently determine if the trend was positive or negative.

We qualitatively looked for changes in abundance between the early years (1996, 1997, 1998) and the most recent years (2001, 2004) for 89 species. Fully 29% showed positive change, 29% showed negative change, and 43% showed no change. Of these, species that should be "watched" due to large drops in abundance in the recent years include California Towhee, Chipping Sparrow, Golden-crowned Kinglet, Pine Siskin, and Swainson's Thrush. Species that showed a substantial positive change between the two time periods include Lesser Goldfinch, Brown Creeper, Chestnut-backed Chickadee, Anna's Hummingbird, Hutton's Vireo, Wilson's Warbler, and Warbling Vireo.

We recommend modifying the monitoring program of landbirds within the MMWD by implementing 3-year cycles of surveys every three years. This would mean monitoring for three consecutive years, halting monitoring for another three years, and then picking it up again for three more consecutive years, and so on. We believe this would greatly enhance our ability to detect trends of landbird populations. Alternatively, we suggest keeping the current monitoring protocol but waiting until at least 10 sample years of data have been collected before statistically examining trends.

In sum, results presented here suggest that populations of landbirds breeding on MMWD lands were stable over the eight year sampling period.

BACKGROUND AND INTRODUCTION

In recent years, concern has grown over widespread declines of numerous songbird populations, particularly of Neotropical migrants, species breeding in temperate North America and migrating to the southerly tropics. In May of 1996, PRBO Conservation Science (PRBO) and the Marin Municipal Water District (MMWD) implemented a three-year project to assess the status and distribution of bird populations on watershed lands managed by the MMWD (Holmes et al. 1998). This was followed by the initiation of a long-term monitoring plan, where it was determined that all 327 point count stations would be surveyed every third year. Long-term population abundance monitoring is an important tool in conservation; the results of an abundance monitoring program can be used to evaluate ecosystem health (i.e., provide early warning of resource depletion) and thereby inform managers when management actions are warranted and research is needed.

The principal goal of this long-term study is to monitor songbird populations on the MMWD lands over time, allowing the MMWD to assess their land management practices and implement any necessary adjustments. This report summarizes findings on population changes of passerines and near passerines (hereafter songbirds and landbirds) within the study area from initiation of the surveys in 1996 through 2004.

STUDY AREA

Sampling points were first established in 1996 on trails and fire roads throughout the MMWD watershed with the goal of covering the major habitat types and geographic extent of the study area. General habitat types covered include mixed evergreen hardwood forest, oak woodland / savannah, coast redwood forest, chaparral, and grassland/edge.

Individual survey points are clumped into transects, and points within a transect are generally spaced 200-400m apart from one another (Table 1). The total number of points included in this analysis is 327. See Appendix A for details of points excluded from analysis and additional metadata on some of the points included.

Table 1. Point count transects within the MMWD included in trend analysis, 1996 – 2004.

Station Name / Location	Station Code	No. of Points
Berry/Bon Tempe Trail	BETR	3
Blithdale Ridge Road	BLRI	15
Bolinas Ridge Road	BORT	25
Bull Frog/Bon Tempe Road	BURO	8
Cataract Trail	CATR	17
Colier Springs Trail	COST	9
Concrete Pipe Road	COPT	5
Eldridge Grade	ELGR	18
Helen Mark Trail	HEMA	18
Hidden Cove/Pine Point	HICO	6
Hoo-Koo-E-Koo Road	HOKE	17
Kent Pump Road	KPFR	30
Lakeview Road	LAVR	6
Laurel Dell/ Lagunitas-Rock Spring Road	LADE	9
Matt Davis Trail	MDTR	14
Oat Hill Road	OHFR	13
Old Stage Road	OSRO	21
Pine Mountain Road	PIMR	20
Rocky Ridge/Lagunitas-Rock Spring Road	RRFR	12
San Geronimo Ridge Road	SGRT	16
Peter's Dam/Shafter Grade	SHAF	15
Shafter Creek	SHCR	3
Shaver Grade	SHGR	14
Six Points Trail	SPTR	3
Yolanda Trail	YOTR	10
Total	25 transects	327

METHODS

Point Count Surveys

Point count surveys of landbird populations are used to measure secondary population parameters of birds (such as abundance, species richness and species diversity). Repeatable point count surveys were conducted following standardized point count protocol as described in Ralph et al. (1993 and 1995). The Variable Circular Plot (VCP) point count method uses estimations of distance from the observer to all birds detected within 100 m, during a 5-minute period, at each point. This method of point count survey was used in all years following the initial year of the study. In 1997, 1998, and 2001, the VCP distance bands were 10 m bands out to 100m; in 2004, we moved to slightly broader VCP distance bands of 0-10m, 10-20m, 20-30m, 30-50m, 50-75m, and 75-100m. In 1996, fixed

radius point count surveys were done, when distance bands of the birds detected were broader, at less than 50 m and greater than 50 meters. However, we are able to compare all years of this study by lumping all detections up to 50 m into one distance band. In latter years of the study all field biologists used range finders to assist in the accurate determination of distance estimations; during all years biologists regularly recalibrated their distance estimations.

The type of detection (song, visual, or call) was noted. Surveys began within a half hour after local sunrise and continued for no more than four hours in order to restrict the survey to peak singing hours. Counts were not conducted during excessively rainy, foggy, or windy conditions, where bird activity levels or detection probability was reduced. Two surveys were conducted each year from mid-April through mid-July, and generally occurring in May and June; in 1997 three surveys were conducted but only two are included in this analysis (Appendix B).

Statistical Analysis

In the single year (1997) in which three surveys were conducted, we eliminated all data from one of the visits for each transect to make this year comparable to all years for these analyses. We chose to exclude whichever visit (the first or third) was an outlier when compared to dates the same transect was surveyed in all other years (Appendix B).

For trend analysis, we attempted to examine the entire suite of landbird species for which species accounts were done using 1996-1998 MMWD data (Holmes et al.1998). We also included some species not included in that analysis for which we felt we might have sufficient sample size to detect a trend, for a total of 53 species examined. We excluded all waterbirds (e.g., ducks, herons, coots, grebes); shorebirds; owls; nonbreeding species (e.g., Ruby-crowned Kinglets, Fox Sparrows); species not well sampled for densities with the point count method such as non-territorial species, flocking species, or species with very large territories (e.g., swallows, ravens, crows, raptors); and species with very low sample sizes (less than 10 detections in total, e.g., Black-chinned Hummingbird, California Thrasher, Blue Grosbeak). For scientific names of species included in analysis, see Appendix C.

The protocol for how to record juvenile birds during point count surveys changed for all PRBO projects halfway through this study. In 1996, 1997, and 1998, how juveniles were recorded, or if they were recorded, was inconsistent. In 2001 and 2004 we recorded them separately from adults and gave each juvenile a record in the database coded to easily separate them from adult

observations. We went through our juvenile data and determined that the number of sightings was so low, both overall and per species, that they could be removed from analysis.

For all species we determined their relative abundance by dividing the total number of detections by the total number of points (327) and the number of visits (2).

Because we used the exact same number of points and visits each year in our analyses, we used the total number of detections of each species within 50 meters each year for statistical analysis of trends. We modeled trends in log total individuals detected (plus 1 to allow log transformation of zeroes) for each year using linear models (Neter et al. 1990). We also tested higher order polynomials for better fits in all cases by including year^2 and year^3 in the models. All analyses were carried out using the program STATA (Stata Corp 1999). We examined whether data were normally distributed using the *hettest* available in STATA (Stata Corp 1999).

We provide an example of our regression models that we ran for each species as well as all species combined in Appendix D.

In addition to formal trend analyses, we also looked for very general species-specific changes over time by comparing the mean abundances of each species during the earlier years of monitoring (1996, 1997 and 1998 combined) to the mean abundances during the later years of monitoring (2001 and 2004). Once we determined the means during each of these two time periods, we qualitatively examined the differences for the presence of any interesting patterns.

Personnel

PRBO staff biologists and experienced volunteers, trained in the songs and calls of the birds in the area, conducted all surveys in 2004. These were PRBO staff Tom Gardali, Diana Humple, Diana Stralberg, Viola Toniolo, and Grant Ballard, and volunteers Mike Lynes, Sandy Scoggin, and Eric Preston. For a list of personnel between the years 1996 and 1998 see Holmes et al. (1998), and for 2001 see Flannery et al. (2002). In 2004, PRBO staff biologist Tom Gardali coordinated the project under the supervision of Terrestrial Division Director, Geoffrey R. Geupel.

RESULTS

We detected a total of 103 species within the MMWD across all five years of survey. The relative abundance of each species is presented in Appendix E. The most common species within 50 meters across all points, in order of abundance, were Pacific Slope Flycatcher, Chestnut-backed Chickadee, Spotted Towhee, Oregon Junco, Warbling Vireo, Bewick's Wren, Wrentit, Bushtit, Wilson's

Warbler, Orange-crowned Warbler, Anna's Hummingbird, Western Scrub-Jay, Steller's Jay, and Black-throated Gray Warbler.

We found a statistically significant linear trend for only one species, Cassin's Vireo (Table 2), although we have little faith in this result because the 95% Confidence Interval contained zero. Fully 52 of the 53 species examined had 95% Confidence Intervals that contained zero (Table 2).

We found quadratic statistically significant trends for two species, Bushtit and American Robin, and the results for all species are presented in (Table 3). Both of these quadratic trends were negative and have 95% Confidence Intervals that were also negative. Additionally, the adjusted R-squared values (0.8977 and 0.963, respectively) were high.

We did not find significant linear, quadratic (although that was near-significant), or cubic trends when examining the abundance of all species combined.

Comparisons of the mean abundances of 89 individual species within 50 meters between the earlier years of the study (1996-1998) to the means of the later years of the study (2001-2004), showed a negative change for 26 species (29%), a positive change for 26 species (29%), and no substantial change for 38 species (43%). However, while we present the data for all the species in Table 4, we limit our discussion to species for which the differences we found do not appear to be driven by an outlying year but rather seem to be a consistent change. We also eliminate discussion of species for which samples sizes were very low.

The abundances of some of the more common species were remarkably similar during the two periods, suggesting a lack of change in their populations within the MMWD but also providing validation for our methodology. For example, we found very similar numbers of the following species between the earlier and later years: Allen's Hummingbird (60 detections per year and 63, respectively), Red-shafted Flicker (17 and 16), Acorn Woodpecker (40 and 41), Mourning Dove (41 and 42), Winter Wren (39 and 39), Wrentits (201 and 199); American Robin (43 and 40), Oregon Junco (294 and 295), and Spotted Towhee (330 and 308).

We observed potential decreases in a few species that are worth mentioning. These included California Towhee (56 to 35), Chipping Sparrow (14 to 7), Golden-crowned Kinglet (61 to 37), Pine Siskin (24 to 0), and Swainson's Thrush (70 to 20).

Species that showed a positive change between the two time periods include Lesser Goldfinch, Brown Creeper, Chestnut-backed Chickadee, Anna's Hummingbird, Hutton's Vireo, Wilson's Warbler, and Warbling Vireo.

Table 2. Regression statistics for 53 species within the MMWD from 1996 to 2004 across 327 point count stations, using data within 50 m from 1996-1998, 2001, and 2004. In **bold** are species whose p-value indicated a statistically significant trend; but see discussion in test.

Species	Coeff. of Variance	SE	P value	Adjusted R^2	Lower Confidence Limit	Upper Confidence Limit
Acorn Woodpecker	-0.0235	0.0448	0.6363	-0.2214	-0.1659	0.119
Allen's Hummingbird	0.01	0.0831	0.9119	-0.3269	-0.2543	0.2743
American Robin	-0.0399	0.0588	0.5456	-0.1555	-0.227	0.1471
Anna's Hummingbird	0.1749	0.0374	0.0184	0.8394	0.0557	0.2939
Ash-throated Flycatcher	-0.0195	0.0867	0.8364	-0.3112	-0.2996	0.2565
Audubon's Warbler	0.1067	0.2168	0.6564	-0.2337	-0.5834	0.7968
Band-tailed Pigeon	0.0632	0.0368	0.1842	0.3282	-0.0538	0.1802
Bewick's Wren	-0.001	0.0463	0.9834	-0.3331	-0.1485	0.1464
Black-headed Grosbeak	0.0905	0.0607	0.2329	0.2339	-0.1027	0.2837
Black Phoebe	0.13	0.1156	0.3427	0.0619	-0.238	0.4981
Black-throated Gray Warbler	0.0161	0.0638	0.817	-0.3056	-0.187	0.2193
Blue-gray Gnatcatcher	-0.0157	0.1821	0.9368	-0.3301	-0.5952	0.5638
Brown-headed Cowbird	0.006	0.1439	0.9694	-0.3326	-0.4521	0.4641
Brown Creeper	0.0685	0.0816	0.4632	-0.0801	-0.1913	0.3282
Bushtit	0.0453	0.0422	0.3614	0.0371	-0.089	0.1796
California Quail	0.0456	0.0584	0.4921	-0.1083	-0.1403	0.2314
California Towhee	-0.0672	0.0336	0.1397	0.4276	-0.1742	0.0399
Cassin's Vireo	**-0.2263**	**0.0652**	**0.0403**	**0.7341**	**-0.4338**	**0.0187**
Chestnut-backed Chickadee	0.0462	0.0243	0.1533	0.3956	-0.0311	0.1236
Chipping Sparrow	-0.1843	0.0772	0.097	0.5401	-0.4301	0.0614
Downy Woodpecker	-0.0373	0.0785	0.6669	-0.2399	-0.2871	0.2124
Golden-crowned Kinglet	-0.0987	0.0344	0.064	0.6441	-0.2081	0.0107
Hairy Woodpecker	0.0369	0.046	0.4811	-0.0978	-0.1095	0.1834
Hermit Thrush	0.0603	0.1152	0.6368	-0.2217	-0.3063	0.427
Hermit Warbler	-0.0015	0.1384	0.9918	-0.3333	-0.442	0.4389
House Finch	0.048	0.1325	0.7412	-0.2775	-0.3736	0.4695
Hutton's Vireo	0.0526	0.0531	0.3949	-0.0047	-0.1164	0.2216
Lark Sparrow	-0.1734	0.0947	0.1647	0.3698	-0.4751	0.1282
Lazuli Bunting	0.0056	0.1973	0.9793	-0.333	-0.6222	0.6331
Lesser Goldfinch	0.3098	0.1944	0.2092	0.278	-0.3088	0.9283
Mourning Dove	-0.0941	0.0818	0.3334	0.0747	-0.3546	0.1663
Nuttall's Woodpecker	0.1404	0.1463	0.408	-0.0202	-0.3252	0.606
Oak Titmouse	-0.0362	0.0843	0.6963	-0.256	-0.3044	0.2319
Olive-sided Flycatcher	0.1085	0.1148	0.4143	-0.0273	-0.2568	0.4738
Orange-crowned Warbler	-0.0459	0.0838	0.6222	-0.2122	-0.3126	0.2208
Oregon Junco	0.0047	0.0204	0.8312	-0.3098	-0.0601	0.0695
Pileated Woodpecker	0.0131	0.0286	0.6786	-0.2465	-0.0779	0.104
Purple Finch	-0.0155	0.0457	0.7566	-0.284	-0.1611	0.13
Pygmy Nuthatch	0.2567	0.0894	0.064	0.6441	-0.0279	0.5414
Red-breasted Nuthatch	-0.0083	0.0969	0.9375	-0.3301	-0.3168	0.3002
Red-shafted Flicker	-0.0859	0.1129	0.5018	-0.1174	-0.4451	0.2733
Rufous-crowned Sparrow	-0.0763	0.1173	0.5619	-0.1686	-0.4497	0.2971
Song Sparrow	0.0458	0.033	0.2597	0.1874	-0.0593	0.1509
Spotted Towhee	-0.0219	0.0214	0.3823	0.0106	-0.09	0.0463

Species	Coeff. of Variance	SE	P value	Adjusted R^2	Lower Confidence Limit	Upper Confidence Limit
Steller's Jay	-0.0886	0.0434	0.1339	0.4419	-0.2266	0.0495
Swainson's Thrush	-0.2505	0.1143	0.1161	0.4873	-0.6142	0.1133
Warbling Vireo	-0.0014	0.0381	0.9724	-0.3327	-0.1227	0.1198
Western Bluebird	0.1157	0.1116	0.3763	0.0182	-0.2395	0.4709
Western Scrub-Jay	-0.0641	0.0597	0.361	0.0376	-0.254	0.1257
Western Wood-Pewee	-0.0232	0.1622	-0.8953	-0.3243	-0.5395	0.4931
Wilson's Warbler	0.0739	0.0426	0.181	0.3347	-0.0616	0.2095
Winter Wren	0.0067	0.0455	0.8938	-0.324	-0.1383	0.1515
Wrentit	-0.0224	0.0284	0.4884	-0.1049	-0.1128	0.068
Total abundance	0.0038	0.0245	0.9028	-0.3256	-0.0746	0.0811

Table 3. Quadratic regression analysis of 53 species within the MMWD from 1996 to 2004 across 327 point count stations, using data within 50 m from 1996-1998, 2001, and 2004. In **bold** are species whose p-value indicated a statistically significant trend; but see discussion in test.

Species	Coeff. of Variance	SE	P value	Adjusted R^2	Lower Confidence Limit	Upper Confidence Limit
Acorn Woodpecker	-0.035	0.0087	0.1009	0.7981	-0.0725	0.0025
Allen's Hummingbird	0.0595	0.0245	0.2524	0.4953	-0.046	0.1651
American Robin	**-0.0482**	**0.005**	**0.0185**	**0.963**	**-0.0699**	**-0.0266**
Anna's Hummingbird	0.0275	0.0102	0.026	0.948	-0.0163	0.0713
Ash-throated Flycatcher	-0.0561	0.0319	0.3863	0.2274	-0.1933	0.0811
Audubon's Warbler	-0.1467	0.0735	0.3094	0.3812	-0.4632	0.1697
Bewick's Wren	-0.001	0.0463	0.9834	-0.3331	-0.1485	0.1464
Band-tailed Pigeon	-0.0242	0.0132	0.1875	0.6251	-0.0808	0.0324
Black-headed Grosbeak	-0.0285	0.0294	0.3903	0.2195	-0.1548	0.0978
Black Phoebe	-0.0777	0.0397	0.2415	0.5169	-0.2488	0.0933
Black-throated Gray Warbler	-0.0509	0.0102	0.0728	0.8543	-0.0949	-0.007
Blue-gray Gnatcatcher	0.0437	0.1022	0.914	-0.8279	-0.3962	0.4836
Brown-headed Cowbird	-0.0462	0.0779	0.8499	-0.6997	-0.3812	0.2888
Brown Creeper	0.021	0.0455	0.732	-0.464	-0.1748	0.2168
Bushtit	**-0.0337**	**0.0066**	**0.0511**	**0.8977**	**-0.0621**	**-0.0054**
California Towhee	-0.0113	0.018	0.3582	0.2836	-0.0889	0.0662
California Quail	0.0456	0.0584	0.4921	-0.1083	-0.1403	0.2314
Cassin's Vireo	-0.0175	0.0362	0.1785	0.643	-0.1732	0.1382
Chestnut-backed Chickadee	-0.0128	0.011	0.2697	0.4607	-0.0601	0.0345
Chipping Sparrow	-0.0239	0.042	0.297	0.406	-0.2047	0.1569
Downy Woodpecker	0.0171	0.0444	0.8659	-0.7318	-0.174	0.2082
Golden-crowned Kinglet	0.0003	0.0202	0.2669	0.4663	-0.0864	0.0871
Hairy Woodpecker	0.002	0.027	0.8211	-0.6423	-0.114	0.118
Hermit Thrush	0.0755	0.0415	0.3451	0.3099	-0.103	0.2539
Hermit Warbler	0.0149	0.0805	0.9832	-0.9663	-0.3315	0.3612
House Finch	-0.0538	0.0677	0.7284	-0.4567	-0.3452	0.2376
Hutton's Vireo	-0.039	0.0144	0.1615	0.6771	-0.1011	0.023
Lark Sparrow	-0.0725	0.0214	0.0703	0.8594	-0.1648	0.0197
Lazuli Bunting	-0.143	0.0517	0.2356	0.5287	-0.0986	0.3847
Lesser Goldfinch	0.0162	0.1134	0.5361	-0.0721	-0.4719	0.5042

Species	Coeff. of Variance	SE	P value	Adjusted R^2	Lower Confidence Limit	Upper Confidence Limit
Mourning Dove	-0.0525	0.0305	0.2793	0.4413	-0.1835	0.0786
Nuttall's Woodpecker	-0.0882	0.056	0.3614	0.2772	-0.3419	0.1656
Oak Titmouse	-0.0113	0.0488	0.9172	-0.8344	-0.2212	0.1985
Olive-sided Flycatcher	-0.0071	0.0671	0.7662	-0.5323	-0.296	0.2817
Orange-crowned Warbler	-0.0562	0.029	0.3159	0.3683	-0.1808	0.0685
Oregon Junco	-0.013	0.0077	0.4034	0.1933	-0.0459	0.02
Pileated Woodpecker	0.0193	0.0097	0.3151	0.3697	-0.0226	0.0612
Purple Finch	-0.0304	0.0161	0.3449	0.3101	-0.0995	0.0387
Pygmy Nuthatch	0.0184	0.0508	0.2504	0.4992	-0.2002	0.2371
Red-breasted Nuthatch	-0.0436	0.0478	0.7041	-0.4081	-0.2491	0.1619
Red-shafted Flicker	-0.0509	0.0554	0.5899	-0.1799	-0.2899	0.188
Rufous-crowned Sparrow	-0.0213	0.0671	0.8347	-0.6693	-0.3102	0.2677
Song Sparrow	-0.0246	0.0085	0.1163	0.7674	-0.061	0.0118
Spotted Towhee	-0.0153	0.0063	0.1891	0.6219	-0.0426	0.0119
Steller's Jay	-0.0253	0.0181	0.211	0.5779	-0.1031	0.0524
Swainson's Thrush	-0.0832	0.0322	0.0885	0.823	-0.2216	0.0552
Warbling Vireo	-0.0063	0.0219	0.9602	-0.9204	-0.1005	0.088
Western Bluebird	-0.0468	0.0565	0.5485	-0.097	-0.2899	0.1963
Western Scrub-Jay	-0.0418	0.0188	0.2078	0.5843	-0.1225	0.039
Western Wood-Pewee	-0.0446	0.09	0.8839	-0.7678	-0.4309	0.3416
Wilson's Warbler	-0.03	0.0132	0.1391	0.7219	-0.0868	0.0267
Winter Wren	-0.0302	0.0161	0.3593	0.2814	-0.0993	0.039
Wrentit	-0.0206	0.008	0.1926	0.6148	-0.0552	0.0139
Total abundance	-0.0197	0.0034	0.0570	0.8860	-0.0345	-0.0049

Table 4. Total numbers of each species detected annually (2 visits, all 327 points combined, within 50 m only, using reduced species list as described in methods), mean number detect during the earlier years of monitoring versus later years, and direction of trend for each species, MMWD, 1996-2004.

Species	1996	1997	1998	2001	2004	96-98 mean	01-04 mean	Direction of change
Acorn Woodpecker	36	38	45	55	27	39.67	41.00	None
Allen's Hummingbird	102	48	31	46	79	60.33	62.50	None
American Crow	3	14	20	14	11	12.33	12.50	None
American Goldfinch	1	7	5	3	4	4.33	3.50	None
American Kestrel	0	0	0	1	0	0.00	0.50	None
American Robin	31	47	51	55	24	43.00	39.50	None
Anna's Hummingbird	76	62	64	121	265	67.33	193.00	Positive
Ash-throated Flycatcher	12	20	13	32	9	15.00	20.50	Positive
Audubon's Warbler	2	1	7	25	2	3.33	13.50	Positive
Barn Swallow	6	6	3	0	1	5.00	0.50	Negative
Belted Kingfisher	1	1	3	0	0	1.67	0.00	None
Bewick's Wren	169	206	183	299	151	186.00	225.00	Positive
Blue-gray Gnatcatcher	2	13	6	1	7	7.00	4.00	Negative
Brown-headed Cowbird	5	1	4	8	2	3.33	5.00	Positive
Black-headed Grosbeak	2	5	3	6	5	3.33	5.50	Positive
Blue Grosbeak	0	1	0	0	0	0.33	0.00	None

Species	1996	1997	1998	2001	2004	96-98 mean	01-04 mean	Direction of change
Black Phoebe	0	3	6	5	4	3.00	4.50	Positive
Brewer's Blackbird	0	4	1	6	1	1.67	3.50	Positive
Brown Creeper	71	48	25	90	77	48.00	83.50	Positive
Band-tailed Pigeon	17	21	33	31	31	23.67	31.00	Positive
Black-throated Gray Warbler	40	67	94	92	53	67.00	72.50	Positive
Bushtit	95	149	164	206	150	136.00	178.00	Positive
California Towhee	44	63	61	37	33	56.00	35.00	Negative
California Quail	16	25	31	43	24	24.00	33.50	Positive
California Thrasher	0	2	1	0	2	1.00	1.00	None
Cassin's Vireo	3	8	3	1	0	4.67	0.50	Negative
Chestnut-backed Chickadee	298	259	348	437	380	301.67	408.50	Positive
Cedar Waxwing	0	0	0	1	0	0.00	0.50	None
Chipping Sparrow	14	21	7	11	3	14.00	7.00	Negative
Cliff Swallow	1	0	3	0	15	1.33	7.50	Positive
Cooper's Hawk	0	1	1	0	0	0.67	0.00	None
Common Raven	3	7	7	3	1	5.67	2.00	Negative
Downy Woodpecker	9	18	5	8	8	10.67	8.00	Negative
European Starling	2	2	13	6	0	5.67	3.00	Negative
Golden-crowned Kinglet	81	44	57	45	29	60.67	37.00	Negative
Great Horned Owl	1	1	0	0	0	0.67	0.00	None
Grasshopper Sparrow	0	3	0	0	1	1.00	0.50	None
Hairy Woodpecker	14	19	10	20	18	14.33	19.00	Positive
Hermit Thrush	23	17	5	13	29	15.00	21.00	Positive
Hermit Warbler	5	25	3	7	8	11.00	7.50	Negative
House Finch	3	20	5	14	7	9.33	10.50	None
Hooded Oriole	0	0	0	0	1	0.00	0.50	None
House Wren	5	0	0	0	0	1.67	0.00	Negative
Hutton's Vireo	42	54	56	107	57	50.67	82.00	Positive
Killdeer	1	1	2	1	0	1.33	0.50	None
Lark Sparrow	3	6	4	5	0	4.33	2.50	Negative
Lazuli Bunting	5	7	0	0	8	4.00	4.00	None
Lesser Goldfinch	5	5	0	42	28	3.33	35.00	Positive
MacGillivray's Warbler	3	0	0	0	0	1.00	0.00	None
Mourning Dove	46	37	40	68	15	41.00	41.50	None
Northern Mockingbird	0	0	0	1	0	0.00	0.50	None
Northern Rough-winged Swallow	2	0	0	0	0	0.67	0.00	None
Nuttall's Woodpecker	1	0	3	12	2	1.33	7.00	Positive
Oak Titmouse	34	77	22	49	28	44.33	38.50	Negative
Orange-crowned Warbler	82	101	244	126	67	142.33	96.50	Negative
Oregon Junco	243	319	321	307	282	294.33	294.50	None
Olive-sided Flycatcher	1	5	4	2	6	3.33	4.00	None
Osprey	3	2	4	1	2	3.00	1.50	Negative
Pine Siskin	9	16	48	0	0	24.33	0.00	Negative
Pileated Woodpecker	6	5	4	5	6	5.00	5.50	None
Pacific-slope Flycatcher	318	448	486	409	290	417.33	349.50	Negative
Purple Finch	43	76	76	65	48	65.00	56.50	Negative
Pygmy Nuthatch	1	0	0	5	7	0.33	6.00	Positive
Red-breasted Nuthatch	30	30	19	71	18	26.33	44.50	Positive

Species	1996	1997	1998	2001	2004	96-98 mean	01-04 mean	Direction of change
Rufous-crowned Sparrow	15	3	12	10	4	10.00	7.00	Negative
Red Crossbill	0	1	1	1	0	0.67	0.50	None
Red-shafted Flicker	12	31	9	26	6	17.33	16.00	None
Red-shouldered Hawk	0	2	4	2	2	2.00	2.00	None
Red-tailed Hawk	0	4	1	0	3	1.67	1.50	None
Red-winged Blackbird	10	26	30	14	9	22.00	11.50	Negative
Savannah Sparrow	0	0	0	0	1	0.00	0.50	None
Song Sparrow	11	16	19	20	18	15.33	19.00	Positive
Spotted Towhee	300	364	326	357	258	330.00	307.50	Negative
Sharp-shinned Hawk	0	1	0	0	0	0.33	0.00	None
Steller's Jay	92	104	75	98	41	90.33	69.50	Negative
Swainson's Thrush	32	88	91	33	7	70.33	20.00	Negative
Tree Swallow	2	10	21	2	5	11.00	3.50	Negative
Turkey Vulture	0	2	7	3	0	3.00	1.50	Negative
Violet-green Swallow	2	6	8	4	13	5.33	8.50	Positive
Warbling Vireo	240	190	166	281	183	198.67	232.00	Positive
White-breasted Nuthatch	1	8	0	1	0	3.00	0.50	Negative
Western Bluebird	0	2	6	2	4	2.67	3.00	None
Western Scrub-Jay	98	131	102	153	54	110.33	103.50	None
Western Tanager	1	1	0	3	1	0.67	2.00	None
Western Wood-Pewee	0	11	1	2	1	4.00	1.50	None
Wilson's Warbler	78	108	169	166	160	118.33	163.00	Positive
Winter Wren	31	31	55	45	33	39.00	39.00	None
Wrentit	199	194	211	246	151	201.33	198.50	None
Yellow Warbler	0	1	0	0	0	0.33	0.00	None

DISCUSSION

Our results are difficult to interpret because at this point too few years have been sampled to provide precise population trends. Further, our comparisons of abundance between the early and the more recent years reflect a variety of scenarios including natural annual variation. Nonetheless, some species showed substantial negative changes, suggesting that attempts should be made to minimize any potentially negative impacts to their populations.

Our data reveal negative trends for American Robin, Bushtit, and Cassin's Vireo. To put these results into context we made comparisons with the Breeding Bird Survey (BBS) during approximately the same time period. The BBS is a breeding season survey widely used to analyze changes in population sizes of birds in North America (e.g., Robbins et al. 1989, Peterjohn et al. 1995), and as a benchmark against which many researchers have compared population trend estimates (e.g., Ballard et al. 2003). BBS showed no significant trend for Cassin's Vireo, Bushtit, or American Robin in California (Sauer et al. 2004). However, long-

term trend analysis from the nearby Palomarin Field Station revealed a negative trend for Bushtits in autumn (Ballard et al. 2004); these authors were unable to look at Cassin's Vireos or American Robins because of sample size constraints at that site.

In our comparisons between time periods we observed potential decreases in a five species; California Towhee (56 to 35), Chipping Sparrow (14 to 7), Golden-crowned Kinglet (61 to 37), Pine Siskin (24 to 0), and Swainson's Thrush (70 to 20). The Chipping Sparrow is a California Partners in Flight (CalPIF) Focal Species under the Coniferous Forest Bird Conservation Plan (CalPIF 2002), where it was included due to worry that this species may be falling outside of the radar of many habitat plans because of its affinity towards edgy, brushy habitat; BBS data reveals a significant decline during the similar time period as this study (Sauer et al. 2004). Swainson's Thrush is also a CalPIF focal species under the Riparian Plan (RHJV 2004), and is currently a candidate for inclusion as a California Bird Species of Special Concern; coastal populations have been thought to be fairly stable compared to the historically declining populations in the Sierra Nevada (Evans Mack and Yong 2000), but the data here indicates that these coastal populations deserve further investigation. The overall population in California from 1995-2003 is undergoing no significant change according to BBS data (Sauer et al. 2004). The negative change observed for California Towhees also deserves attention, as this species hasn't been thought to be of conservation concern because of its purported stability and ability to exist in suburban environments. However, BBS data also showed a near-significant negative trend (Sauer et al. 2004). The change in abundance for Golden-crowned Kinglet (also a CalPIF [2000] focal species for coniferous forests) is more difficult to interpret because they were very abundant in one of the early years (1996) and very rare in 2004. Kinglets are very small songbirds and their populations may naturally fluctuate at these levels if, for example, a particularly severe winter reduced survival. BBS data for this kinglet do not reveal declines during this period (Sauer et al. 2004). Pine Siskins were absent in both 2001 and 2004, and this absence could be due to changes in conifer seed abundance during this monitoring period, a food source that by nature is variable year to year. Nevertheless, a highly significant decline has been shown in California for this species from 1995-2003, and a significant decline has been shown from 1966-2003 (Sauer et al. 2004).

Seven species showed possible increases between the two time periods; Lesser Goldfinch, Brown Creeper, Chestnut-backed Chickadee, Anna's Hummingbird, Hutton's Vireo, Wilson's Warbler, and Warbling Vireo. The Warbling Vireo is of particular interest because of apparently

severe declines at the nearby Palomarin Field Station during the breeding season (Gardali et al. 2000), during migration (Ballard et al. 2003), and for BBS in California (Sauer et al. 2004).

Corvids (e.g., jays, crows, ravens) are known nest predators and increases in their populations due to a positive association with human-dominated landscapes may be unnaturally negatively impacting populations of some species (e.g., Vigallon and Marzluff 2005). We did not observe increases in any of the Corvid populations. Both Western Scrub-Jays (110 and 104 detections, respectively) and American Crow (12 and 13) showed no change at all during this period, and Steller's Jay numbers suggest a decline (90 vs. 60), although this may be driven by 2004 during which they were exceptionally less abundant. From 1995-2003, BBS data showed Steller's Jays to be significantly increasing in California, while American Crows and Western Scrub-Jays show no significant trend (Sauer et al. 2004).

FUTURE RECOMMENDATIONS

The results from our analyses of annual abundance over time reveal that not enough data are in hand to precisely estimate population trends. More survey years will remedy this. A power analysis would help to design the most efficient survey protocol by elucidating the sample sizes relative to the study duration required to estimate a population trend of a predefined magnitude. In the absence of a power analysis, we believe that ten years of survey will be sufficient to estimate population trends for many species. Under the current protocol, trend analyses should be repeated in 2019. Another approach that would speed up our ability to estimate trends but still allow us to avoid annual counts of all point count stations would be to survey for three consecutive years every three years (for instance, in 2004, 2005, and 2006, then again in 2009, 2010, and 2011).

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Appendix A. Metadata on points excluded or whose identification numbers were modified for the 1996-2004 trend analysis.

- Deleted all Ridgecrest Boulevard (RICR) points from analyses because visit 1 in 2001 was missing from the electronic data files, and we couldn't find the raw data for that year [possibly only one visit was done]. Additionally, several survey points are along a paved road and detections were very few. Finally, dropping it made survey effort consistent among all 5 years included in analysis.

- Didn't include 1999 because only some transects – and additional ones – were done that year. This year was the focus of a "trail width" study and not part of the overall trend monitoring project.

- Helen Mark Trail (HEMA) – this transect has 19 points, 1-19. However in 1996, there were 20 points (1-20) for visit 1, but for visit 2, there was no point 3. Hence, we deleted point 20 from the one year we had it (1996), and point 3 from all years.

- Lakeview Road (LAVR) – in all years except 1996, the 6 points of this transect were 1-6. However in 1996 they were 10-15, so for this analysis I switched them, respectively, for 1-6. This was because in 1996 they were considered Colier Springs Trail (COST) points 10-15, but when someone changed the name of the transect, they originally kept the points the same as they were initially named.

- Shaver Grade (SHGR) – in all years except 1996, there were 15 points at this transect. In 1996 there were only 14 points, so we deleted point number 15 from the subsequent years for this trend analysis.

Appendix B. Dates of all point count visits to the MMWD, 1996 through 2004. In 1997 when there were 3 visits to all sites, only two of the visits were included in analysis; we eliminated the date that was the most outlier when compared to different years at the same transect.

Station	Year	First Visit	Second Visit
BETR	1996	6/6/1996	7/2/1996
BETR	1997	6/5/1997	6/23/1997
BETR	1998	5/13/1998	6/9/1998
BETR	2001	5/7/2001	6/26/2001
BETR	2004	5/15/2004	6/9/2004
BLRI	1996	6/19/1996	7/8/1996
BLRI	1997	5/29/1997	6/20/1997
BLRI	1998	4/17/1998	6/3/1998
BLRI	2001	5/15/2001	6/26/2001
BLRI	2004	5/17/2004	6/15/2004
BORT	1996	5/14/1996	6/19/1996
BORT	1997	5/8/1997	6/7/1997
BORT	1998	5/8/1998	6/5/1998
BORT	2001	5/9/2001	7/6/2001
BORT	2004	5/19/2004	6/11/2004
BURO	1996	5/20/1996	6/25/1996
BURO	1997	6/5/1997	7/13/1997
BURO	1998	5/19/1998	6/15/1998
BURO	2001	5/7/2001	6/20/2001
BURO	2004	5/9/2004	6/11/2004
CATR	1996	5/23/1996	6/27/1996
CATR	1997	6/2/1997	7/10/1997
CATR	1998	5/4/1998	6/4/1998
CATR	2001	5/4/2001	6/4/2001
CATR	2004	5/15/2004	6/9/2004
COPT	1996	5/24/1996	6/21/1996
COPT	1997	6/2/1997	7/10/1997
COPT	1998	5/14/1998	6/11/1998
COPT	2001	5/7/2001	6/8/2001
COPT	2004	5/11/2004	6/7/2004
COST	1996	5/30/1996	6/26/1996
COST	1997	6/13/1997	7/14/1997
COST	1998	5/18/1998	6/18/1998
COST	2001	5/22/2001	7/6/2001
COST	2004	5/19/2004	6/15/2004
ELGR	1996	5/30/1996	6/26/1996
ELGR	1997	5/16/1997	6/16/1997
ELGR	1998	5/21/1998	6/16/1998
ELGR	2001	5/17/2001	6/30/2001
ELGR	2004	5/18/2004	6/11/2004
HEMA	1996	6/4/1996	7/2/1996
HEMA	1997	4/29/1997	6/11/1997
HEMA	1998	5/21/1998	6/12/1998
HEMA	2001	5/18/2001	6/11/2001
HEMA	2004	5/18/2004	6/9/2004
HICO	1996	6/16/1996	6/25/1996

Station	Year	First Visit	Second Visit
HICO	1997	6/5/1997	7/13/1997
HICO	1998	5/19/1998	6/15/1998
HICO	2001	5/7/2001	6/20/2001
HICO	2004	5/14/2004	6/11/2004
HOKE	1996	5/24/1996	7/8/1996
HOKE	1997	5/7/1997	6/9/1997
HOKE	1998	5/6/1998	6/2/1998
HOKE	2001	5/11/2001	6/17/2001
HOKE	2004	5/14/2004	6/14/2004
KPFR	1996	5/26/1996	6/12/1996, 6/17/1996
KPFR	1997	5/21/1997	6/17/1997, 6/20/1997
KPFR	1998	4/18/1998, 5/11/1998	5/25/1998, 6/2/1998
KPFR	2001	5/5/2001	6/12/2001, 6/19/2001
KPFR	2004	5/13/2004, 5/19/2004, 6/4/2004	5/19/2004
KPFR	2004	6/4/2004	6/16/2004
LADE	1996	6/12/1996	7/2/1996
LADE	1997	6/6/1997	7/5/1997
LADE	1998	4/21/1998	5/30/1998
LADE	2001	5/4/2001	6/15/2001
LADE	2004	5/14/2004	6/20/2004
LAVR	1996	5/30/1996	6/26/1996
LAVR	1997	4/16/1997	6/13/1997
LAVR	1998	5/18/1998	6/18/1998
LAVR	2001	5/22/2001	7/6/2001
LAVR	2004	5/19/2004	6/15/2004
MDTR	1996	5/16/1996	6/13/1996
MDTR	1997	5/19/1997	6/17/1997
MDTR	1998	4/15/1998	5/26/1998
MDTR	2001	5/4/2001	6/6/2001
MDTR	2004	5/12/2004	6/10/2004
OHFR	1996	5/28/1996	6/23/1996
OHFR	1997	5/6/1997	6/11/1997
OHFR	1998	5/15/1998	6/19/1998
OHFR	2001	5/8/2001	6/6/2001
OHFR	2004	5/19/2004	6/10/2004
OSRO	1996	6/6/1996	7/8/1996
OSRO	1997	5/20/1997	6/18/1997
OSRO	1998	4/16/1998	6/1/1998
OSRO	2001	5/10/2001	6/7/2001
OSRO	2004	5/13/2004	6/16/2004
PIMR	1996	5/14/1996	6/28/1996
PIMR	1997	5/5/1997	6/10/1997
PIMR	1998	5/22/1998	7/2/1998
PIMR	2001	5/8/2001	6/25/2001
PIMR	2004	5/13/2004	6/16/2004 , 6/23/2004
RRFR	1996	6/6/1996	7/2/1996
RRFR	1997	6/5/1997	6/23/1997
RRFR	1998	5/13/1998	6/9/1998
RRFR	2001	5/7/2001	6/26/2001

Station	Year	First Visit	Second Visit
RRFR	2004	5/15/2004	6/9/2004
SGRT	1996	6/3/1996	7/8/1996
SGRT	1997	5/13/1997	6/24/1997, 7/7/1997
SGRT	1998	5/22/1998	6/23/1998
SGRT	2001	5/15/2001	6/7/2001
SGRT	2004	5/20/2004	6/17/2004
SHAF	1996	6/12/1996	7/8/1996
SHAF	1997	5/13/1997	6/16/1997
SHAF	1998	5/5/1998	6/8/1998
SHAF	2001	5/8/2001	6/10/2001
SHAF	2004	5/5/2004	6/12/2004, 6/15/2004
SHCR	1996	6/3/1996	7/8/1996
SHCR	1997	5/13/1997	6/24/1997
SHCR	1998	5/22/1998	6/23/1998
SHCR	2001	5/15/2001	6/7/2001
SHCR	2004	5/20/2004	6/17/2004
SHGR	1996	5/21/1996	6/27/1996
SHGR	1997	6/2/1997	7/10/1997
SHGR	1998	5/14/1998	6/11/1998
SHGR	2001	5/7/2001	6/8/2001
SHGR	2004	5/18/2004	6/9/2004
SPTR	1996	5/24/1996	6/21/1996
SPTR	1997	4/24/1997	6/3/1997
SPTR	1998	5/19/1998	6/16/1998
SPTR	2001	5/14/2001	6/12/2001
SPTR	2004	5/11/2004	6/7/2004
YOTR	1996	6/3/1996	6/26/1996
YOTR	1997	4/24/1997	6/3/1997
YOTR	1998	5/19/1998	6/16/1998
YOTR	2001	5/14/2001	6/12/2001
YOTR	2004	5/15/2004	6/15/2004

Appendix C. Scientific names of bird species presented in the results of this report, MMWD 1996-2004.

English name	Genus	Species
Pied-billed Grebe	*Podilymbus*	*podiceps*
Double-crested Cormorant	*Phalacrocorax*	*auritus*
Great Blue Heron	*Ardea*	*herodias*
American Coot	*Fulica*	*americana*
Killdeer	*Charadrius*	*vociferus*
Spotted Sandpiper	*Actitis*	*macularia*
Mallard	*Anas*	*platyrhynchos*
Common Merganser	*Mergus*	*merganser*
Red-breasted Merganser	*Mergus*	*serrator*
California Quail	*Callipepla*	*californica*
Turkey Vulture	*Cathartes*	*aura*
Sharp-shinned Hawk	*Accipiter*	*striatus*
Cooper's Hawk	*Accipiter*	*cooperii*
Red-shouldered Hawk	*Buteo*	*lineatus*
Red-tailed Hawk	*Buteo*	*jamaicensis*
American Kestrel	*Falco*	*sparverius*
Band-tailed Pigeon	*Patagioenas*	*fasciata*
Mourning Dove	*Zenaida*	*macroura*
Great Horned Owl	*Bubo*	*virginianus*
Black-chinned Hummingbird	*Archilochus*	*alexandri*
Anna's Hummingbird	*Calypte*	*anna*
Allen's Hummingbird	*Selasphorus*	*sasin*
Belted Kingfisher	*Ceryle*	*alcyon*
Nuttall's Woodpecker	*Picoides*	*nuttallii*
Downy Woodpecker	*Picoides*	*pubescens*
Hairy Woodpecker	*Picoides*	*villosus*
Northern Flicker	*Colaptes*	*auratus*
Pileated Woodpecker	*Dryocopus*	*pileatus*
Olive-sided Flycatcher	*Contopus*	*cooperi*
Western Wood-Pewee	*Contopus*	*sordidulus*
Pacific-slope Flycatcher	*Empidonax*	*difficilis*
Black Phoebe	*Sayornis*	*nigricans*
Ash-throated Flycatcher	*Myiarchus*	*cinerascens*
Cassin's Vireo	*Vireo*	*cassinii*
Hutton's Vireo	*Vireo*	*huttoni*
Warbling Vireo	*Vireo*	*gilvus*
Steller's Jay	*Cyanocitta*	*stelleri*
Western Scrub-Jay	*Aphelocoma*	*californica*
American Crow	*Corvus*	*brachyrhynchos*
Common Raven	*Corvus*	*corax*
Tree Swallow	*Tachycineta*	*bicolor*
Violet-green Swallow	*Tachycineta*	*thalassina*
Northern Rough-winged Swallow	*Stelgidopteryx*	*serripennis*
Cliff Swallow	*Petrochelidon*	*pyrrhonota*
Barn Swallow	*Hirundo*	*rustica*
Chestnut-backed Chickadee	*Poecile*	*rufescens*
Oak Titmouse	*Baeolophus*	*inornatus*

English name	Genus	Species
Bushtit	*Psaltriparus*	*minimus*
Red-breasted Nuthatch	*Sitta*	*canadensis*
White-breasted Nuthatch	*Sitta*	*carolinensis*
Pygmy Nuthatch	*Sitta*	*pygmaea*
Brown Creeper	*Certhia*	*americana*
Bewick's Wren	*Thryomanes*	*bewickii*
House Wren	*Troglodytes*	*aedon*
Winter Wren	*Troglodytes*	*troglodytes*
Golden-crowned Kinglet	*Regulus*	*satrapa*
Ruby-crowned Kinglet	*Regulus*	*calendula*
Blue-gray Gnatcatcher	*Polioptila*	*caerulea*
Western Bluebird	*Sialia*	*mexicana*
Swainson's Thrush	*Catharus*	*ustulatus*
Hermit Thrush	*Catharus*	*guttatus*
American Robin	*Turdus*	*migratorius*
Wrentit	*Chamaea*	*fasciata*
Northern Mockingbird	*Mimus*	*polyglottos*
California Thrasher	*Toxostoma*	*redivivum*
European Starling	*Sturnus*	*vulgaris*
Cedar Waxwing	*Bombycilla*	*cedrorum*
Orange-crowned Warbler	*Vermivora*	*celata*
Yellow Warbler	*Dendroica*	*petechia*
Yellow-rumped Warbler	*Dendroica*	*coronata*
Black-throated Gray Warbler	*Dendroica*	*nigrescens*
Townsend's Warbler	*Dendroica*	*townsendi*
Hermit Warbler	*Dendroica*	*occidentalis*
MacGillivray's Warbler	*Oporornis*	*tolmiei*
Wilson's Warbler	*Wilsonia*	*pusilla*
Western Tanager	*Piranga*	*ludoviciana*
Spotted Towhee	*Pipilo*	*maculatus*
California Towhee	*Pipilo*	*crissalis*
Rufous-crowned Sparrow	*Aimophila*	*ruficeps*
Chipping Sparrow	*Spizella*	*passerina*
Lark Sparrow	*Chondestes*	*grammacus*
Sage Sparrow	*Amphispiza*	*belli*
Savannah Sparrow	*Passerculus*	*sandwichensis*
Grasshopper Sparrow	*Ammodramus*	*savannarum*
Fox Sparrow	*Passerella*	*iliaca*
Song Sparrow	*Melospiza*	*melodia*
White-crowned Sparrow	*Zonotrichia*	*leucophrys*
Golden-crowned Sparrow	*Zonotrichia*	*atricapilla*
Dark-eyed Junco	*Junco*	*hyemalis*
Black-headed Grosbeak	*Pheucticus*	*melanocephalus*
Blue Grosbeak	*Passerina*	*caerulea*
Lazuli Bunting	*Passerina*	*amoena*
Red-winged Blackbird	*Agelaius*	*phoeniceus*
Brewer's Blackbird	*Euphagus*	*cyanocephalus*
Brown-headed Cowbird	*Molothrus*	*ater*
Hooded Oriole	*Icterus*	*cucullatus*

English name	**Genus**	**Species**
Purple Finch	*Carpodacus*	*purpureus*
House Finch	*Carpodacus*	*mexicanus*
Red Crossbill	*Loxia*	*curvirostra*
Pine Siskin	*Carduelis*	*pinus*
Lesser Goldfinch	*Carduelis*	*psaltria*
American Goldfinch	*Carduelis*	*tristis*

Appendix D. Sample linear and regression models for landbirds in MMWD.

Linear regression of log-transformed Bewick's Wren abundance over time:

```
. reg lnbewr year

      Source |       SS       df       MS                  Number of obs =       5
-------------+------------------------------               F(  1,     3) =    0.00
       Model |   .00004657     1   .00004657               Prob > F      =  0.9834
    Residual |  .275498061     3  .091832687               R-squared     =  0.0002
-------------+------------------------------               Adj R-squared = -0.3331
       Total |  .275544631     4  .068886158               Root MSE      =  .30304

------------------------------------------------------------------------------
      lnbewr |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        year |  -.0010431   .0463209    -0.02   0.983    -.1484568    .1463706
       _cons |   7.362378   92.60479     0.08   0.942    -287.3474    302.0722
```

Quadratic regression of log-transformed Bewick's Wren abundance over time:

```
. reg lnbewr year year2

      Source |       SS       df       MS                  Number of obs =       5
-------------+------------------------------               F(  2,     2) =    2.09
       Model |  .186250425     2  .093125212               Prob > F      =  0.3241
    Residual |  .089294206     2  .044647103               R-squared     =  0.6759
-------------+------------------------------               Adj R-squared =  0.3519
       Total |  .275544631     4  .068886158               Root MSE      =   .2113

------------------------------------------------------------------------------
      lnbewr |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
        year |   126.3521   61.87118     2.04   0.178    -139.8581    392.5623
       year2 |  -.0315878   .0154675    -2.04   0.178    -.0981392    .0349637
       _cons |  -126347.6   61872.07    -2.04   0.178    -392561.6    139866.5
```

Appendix E. Annual relative abundance (mean number of individuals detected per point) of all species detected within 50 meters of all points, MMWD 1996-2004.

Species	1996 mean	1997 mean	1998 mean	2001 mean	2004 mean
Acorn Woodpecker	0.055	0.058	0.069	0.084	0.041
Allen's Hummingbird	0.156	0.073	0.047	0.070	0.121
American Coot	0.003	0.006	0.020	0.005	0.000
American Crow	0.005	0.021	0.031	0.021	0.017
American Goldfinch	0.002	0.011	0.008	0.005	0.006
American Kestrel	0.000	0.000	0.000	0.002	0.000
American Robin	0.047	0.072	0.078	0.084	0.037
Anna's Hummingbird	0.116	0.095	0.098	0.185	0.405
Ash-throated Flycatcher	0.018	0.031	0.020	0.049	0.014
Audubon's Warbler	0.003	0.002	0.011	0.038	0.003
Barn Swallow	0.009	0.009	0.005	0.000	0.002
Black-chinned Hummingbird	0.003	0.000	0.000	0.000	0.000
Belted Kingfisher	0.002	0.002	0.005	0.000	0.000
Bewick's Wren	0.258	0.315	0.280	0.457	0.231
Blue-gray Gnatcatcher	0.003	0.020	0.009	0.002	0.011
Brown-headed Cowbird	0.008	0.002	0.006	0.012	0.003
Black-headed Grosbeak	0.003	0.008	0.005	0.009	0.008
Blue Grosbeak	0.000	0.002	0.000	0.000	0.000
Black Phoebe	0.000	0.005	0.009	0.008	0.006
Brewer's Blackbird	0.000	0.006	0.002	0.009	0.002
Brown Creeper	0.109	0.073	0.038	0.138	0.118
Band-tailed Pigeon	0.026	0.032	0.050	0.047	0.047
Black-throated Gray Warbler	0.061	0.102	0.144	0.141	0.081
Bushtit	0.145	0.228	0.251	0.315	0.229
California Towhee	0.067	0.096	0.093	0.057	0.050
California Quail	0.024	0.038	0.047	0.066	0.037
California Thrasher	0.000	0.003	0.002	0.000	0.003
Cassin's Vireo	0.005	0.012	0.005	0.002	0.000
Chestnut-backed Chickadee	0.456	0.396	0.532	0.668	0.581
Cedar Waxwing	0.000	0.000	0.000	0.002	0.000
Chipping Sparrow	0.021	0.032	0.011	0.017	0.005
Cliff Swallow	0.002	0.000	0.005	0.000	0.023
Cooper's Hawk	0.000	0.002	0.002	0.000	0.000
Common Merganser	0.005	0.002	0.011	0.000	0.014
Common Raven	0.005	0.011	0.011	0.005	0.002
Double-crested Cormorant	0.000	0.005	0.005	0.003	0.002
Downy Woodpecker	0.014	0.028	0.008	0.012	0.012
European Starling	0.003	0.003	0.020	0.009	0.000
Fox Sparrow	0.000	0.000	0.002	0.000	0.000
Great Blue Heron	0.000	0.000	0.000	0.000	0.002
Golden-crowned Kinglet	0.124	0.067	0.087	0.069	0.044
Golden-crowned Sparrow	0.000	0.002	0.000	0.020	0.000
Great Horned Owl	0.002	0.002	0.000	0.000	0.000
Grasshopper Sparrow	0.000	0.005	0.000	0.000	0.002
Hairy Woodpecker	0.021	0.029	0.015	0.031	0.028
Hermit Thrush	0.035	0.026	0.008	0.020	0.044

Species	1996 mean	1997 mean	1998 mean	2001 mean	2004 mean
Hermit Warbler	0.008	0.038	0.005	0.011	0.012
House Finch	0.005	0.031	0.008	0.021	0.011
Hooded Oriole	0.000	0.000	0.000	0.000	0.002
House Wren	0.008	0.000	0.000	0.000	0.000
Hutton's Vireo	0.064	0.083	0.086	0.164	0.087
Killdeer	0.002	0.002	0.003	0.002	0.000
Lark Sparrow	0.005	0.009	0.006	0.008	0.000
Lazuli Bunting	0.008	0.011	0.000	0.000	0.012
Lesser Goldfinch	0.008	0.008	0.000	0.064	0.043
Mallard	0.005	0.057	0.015	0.005	0.005
MacGillivray's Warbler	0.005	0.000	0.000	0.000	0.000
Mourning Dove	0.070	0.057	0.061	0.104	0.023
Northern Mockingbird	0.000	0.000	0.000	0.002	0.000
Northern Rough-winged Swallow	0.003	0.000	0.000	0.000	0.000
Nuttall's Woodpecker	0.002	0.000	0.005	0.018	0.003
Oak Titmouse	0.052	0.118	0.034	0.075	0.043
Orange-crowned Warbler	0.125	0.154	0.373	0.193	0.102
Oregon Junco	0.372	0.488	0.491	0.469	0.431
Olive-sided Flycatcher	0.002	0.008	0.006	0.003	0.009
Osprey	0.005	0.003	0.006	0.002	0.003
Pied-billed Grebe	0.002	0.002	0.006	0.006	0.009
Pine Siskin	0.014	0.024	0.073	0.000	0.000
Pileated Woodpecker	0.009	0.008	0.006	0.008	0.009
Pacific Slope Flycatcher	0.486	0.685	0.743	0.625	0.443
Purple Finch	0.066	0.116	0.116	0.099	0.073
Pygmy Nuthatch	0.002	0.000	0.000	0.008	0.011
Red-breasted Merganser	0.000	0.003	0.000	0.000	0.000
Red-breasted Nuthatch	0.046	0.046	0.029	0.109	0.028
Ruby-crowned Kinglet	0.009	0.000	0.002	0.000	0.000
Rufous-crowned Sparrow	0.023	0.005	0.018	0.015	0.006
Red Crossbill	0.000	0.002	0.002	0.002	0.000
Red-shafted Flicker	0.018	0.047	0.014	0.040	0.009
Red-shouldered Hawk	0.000	0.003	0.006	0.003	0.003
Red-tailed Hawk	0.000	0.006	0.002	0.000	0.005
Red-winged Blackbird	0.015	0.040	0.046	0.021	0.014
Say's Phoebe	0.000	0.000	0.000	0.000	0.002
Savannah Sparrow	0.000	0.000	0.000	0.000	0.002
Song Sparrow	0.017	0.024	0.029	0.031	0.028
Spotted Sandpiper	0.002	0.000	0.000	0.000	0.000
Spotted Towhee	0.459	0.557	0.498	0.546	0.394
Sharp-shinned Hawk	0.000	0.002	0.000	0.000	0.000
Steller's Jay	0.141	0.159	0.115	0.150	0.063
Swainson's Thrush	0.049	0.135	0.139	0.050	0.011
Townsend's Warbler	0.000	0.000	0.002	0.012	0.005
Tree Swallow	0.003	0.015	0.032	0.003	0.008
Turkey Vulture	0.000	0.003	0.011	0.005	0.000
Violet-green Swallow	0.003	0.009	0.012	0.006	0.020
Warbling Vireo	0.367	0.291	0.254	0.430	0.280

Species	1996 mean	1997 mean	1998 mean	2001 mean	2004 mean
White-breasted Nuthatch	0.002	0.012	0.000	0.002	0.000
Western Bluebird	0.000	0.003	0.009	0.003	0.006
Western Scrub-Jay	0.150	0.200	0.156	0.234	0.083
Western Tanager	0.002	0.002	0.000	0.005	0.002
Western Wood-Pewee	0.000	0.017	0.002	0.003	0.002
Wilson's Warbler	0.119	0.165	0.258	0.254	0.245
Winter Wren	0.047	0.047	0.084	0.069	0.050
Wrentit	0.304	0.297	0.323	0.376	0.231
Yellow Warbler	0.000	0.002	0.000	0.000	0.000