Point Blue

Abundance Patterns of Landbirds in the Marin Municipal Water District: 1996 to 2019

Report to the Marin Municipal Water District

2020

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Point Blue Conservation Science – Point Blue's 160 scientists work to reduce the impacts of climate change, habitat loss, and other environmental threats while developing nature-based solutions to benefit both wildlife and people.

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EXECUTIVE SUMMARY

Many species of birds have declined in recent decades. Therefore, monitoring programs that can detect changes in bird populations are important because they can help inform land managers when additional management action or research may be warranted to protect these species. Point Blue Conservation Science monitored the abundance of landbirds in the Marin Municipal Water District (MMWD) from 1996 to 2019. Using these data, we analyzed trends in abundance for 41 species of birds present during the breeding season. For 27 (65.8%) of the 41 species, there was no statistical evidence ($P > 0.10$) of changes in their populations over the 23 year study period; five (12.2%) species were significantly ($P < 0.05$) increasing, and an additional four (9.8%) species showed marginal ($P < 0.10$ and > 0.05) increases; four (9.8%) species were significantly declining, with an additional one (2.4%) species showing a marginally declining trend. Species with increasing trends included Anna's Hummingbird, Hermit Thrush, Hermit Warbler, Olive-sided Flycatcher, and Wilson's Warbler; species marginally increasing were Audubon's (Yellow-rumped) Warbler, Black-throated Gray Warbler, Hairy Woodpecker, and Oak Titmouse; species with declining trends were Ash-throated Flycatcher, California Scrub-Jay, California Towhee, and Downy Woodpecker; Steller's Jay had a marginally declining trend. For the same 41 species, we compared MMWD trends to trends estimated from two time series (1996-2017 and 1970-2017) of Breeding Bird Survey (BBS) data for all of California. We found more species to be stable, and fewer species declining, on MMWD lands than statewide. The BBS 1970-2017 dataset had a higher percent of species that were increasing compared to MMWD and shorter BBS time series. Given the diversity of habitats and expansive size of the MMWD area, the diversity of birds detected across this study, as well as the status of their trends (with the majority stable or increasing), we suggest that protected lands of the MMWD area are important for maintaining a diverse breeding bird community in Marin County. Point Blue also conducted monitoring at additional grassland points that were established in 2019 as a component of a One Tam grassland study – results from that study are presented in a separate report. We recommend continued monitoring of the avian community at the long-term MMWD monitoring sites in order to keep tracking the status of these species, and to provide information to land managers to understand how this natural resource is doing, and determine if management action is warranted.

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INTRODUCTION

Many bird species have declined in recent decades, including species that are considered to be common (Inger et al. 2015, Rosenberg et al. 2019). These declines may be attributed to multiple factors, including habitat loss and degradation, climate change, pesticide use, domestic or feral cat predation, and other causes (Calvert et al. 2013, Mineau and Whiteside 2013, Pearce-Higgins et al. 2015, Xu et al. 2019). The sensitivity of birds to changing conditions makes them good indicators of ecological change (Carignan and Villard 2002). Monitoring programs are essential components to providing early warning of resource change, and can be used to identify species of conservation concern. Furthermore, when changes are detected through monitoring, recommendations for management or further research may be identified (e.g., Strong et al. 2004).

The Marin Municipal Water District (MMWD) encompasses over 21,000 acres of land in Marin County, including 18,900 on Mount Tamalpais, and 2,700 adjacent to Nicasio and Soulajule Reservoirs. These lands include a diversity of habitat types and wildlife. In 1996, Point Blue Conservation Science (Point Blue; formerly PRBO) and MMWD implemented a three-year project to assess the status and distribution of landbird populations on watershed lands managed by MMWD (Holmes et al. 1998). This was followed by the initiation of a long-term monitoring program, where it was determined that all 337 point count stations would be surveyed every third year. The principal goal of this long-term study is to monitor the abundance of landbird populations on MMWD lands over time in order to provide managers with information on the overall status of this natural resource, which will in turn provide guidance on when management actions are warranted and research is needed.

In this report we present results from trend analysis for 41 passerine and near-passerine species (hereafter collectively called landbirds) within the study area using data from 1996 to 2019. In addition, in 2019, Point Blue established 25 new points in the MMWD study area in grassland habitat with the goal of filling an identified data gap for grassland species in the One Tam region (Edson et al. 2016). The results from the newly-established grassland surveys, along with recommendations for future monitoring, are included in a separate report (DiGaudio and Humple 2019), and not analyzed here as they are outside the scope of assessing long-term trends; however, their locations are presented on the map of the study area (Figure 1).

METHODS

Study area

Point Blue Conservation Science conducted bird surveys at 337 point count stations throughout the Marin Municipal Water District around Mount Tamalpais (Figure 1, Table 1). Point count survey locations were first established in 1996 by Point Blue, in collaboration with MMWD. Points were placed 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.

Point count transect starting points were randomly stratified according to habitat type and distributed throughout the study area. From each random starting point, the nearest unpaved fire road or trail was used for the transect, with points placed on the fire road or trail, and the direction of travel was also random when possible. Individual survey points were clumped into transects, and points within a transect were generally spaced 200-400 meters apart from one another (Figure 1).

In 2019, additional points were established in grassland habitat across the MMWD watershed and other lands within the One Tam footprint to assess grassland bird species. A separate report (DiGaudio and Humple 2019) details site selection and distribution of the new grassland surveys, which are not otherwise described or included here (although see Figure 1); we include mention of the new grassland points simply to highlight all point counts conducted on MMWD lands in 2019.

Point Count Surveys

Point count surveys were conducted following the standardized point count protocol described in Ralph et al (1993 and 1995). At each point count location, an observer recorded all birds detected within a 5-minute survey window. The species of bird, type of detection (song, visual, or call), and the estimated distance of the bird from the observer were all recorded. Methods for recording distance have varied depending on the year and adhered to either a Fixed Radius method or the Variable Circular Plot (VCP) point count method. The Fixed Radius method was used in 1996 and for some sites in 1997 and 1998, where each bird was classified as being less than 50 m or greater than 50 m from the observer. For the VCP method, the distance to each bird is estimated to the nearest “distance band” from the observer. For the remaining points in 1997 and 1998, and for 2001, the VCP method was used with distance bands every 10 m out to 100 m; since 2004 we have used slightly broader VCP distance bands of 0-10 m, 10-20 m, 20-30 m, 30-50 m, 50-100 m, and greater than 100 m. Beginning in 2004, biologists used range finders to assist in the accurate determination of distance estimations; during all years, biologists regularly recalibrated their distance estimations. We were able to compare all years of this study by lumping all detections within 50 m of the observer into one distance band (0-50 m).

Surveys began 15-30 minutes after local sunrise and were completed within four hours of sunrise in order to restrict the survey to peak singing hours. Counts were not conducted during rainy, excessively foggy, or windy conditions, where bird activity levels or detection probability was reduced. In most years, two surveys were conducted each year from mid-April through mid-July, and generally occurring in May and June, with the current protocol being to conduct the first survey in May and the second in June (see Appendix A for survey dates in 2019); see statistical methods for how this we addressed the few instances of one or three surveys being conducted in year.

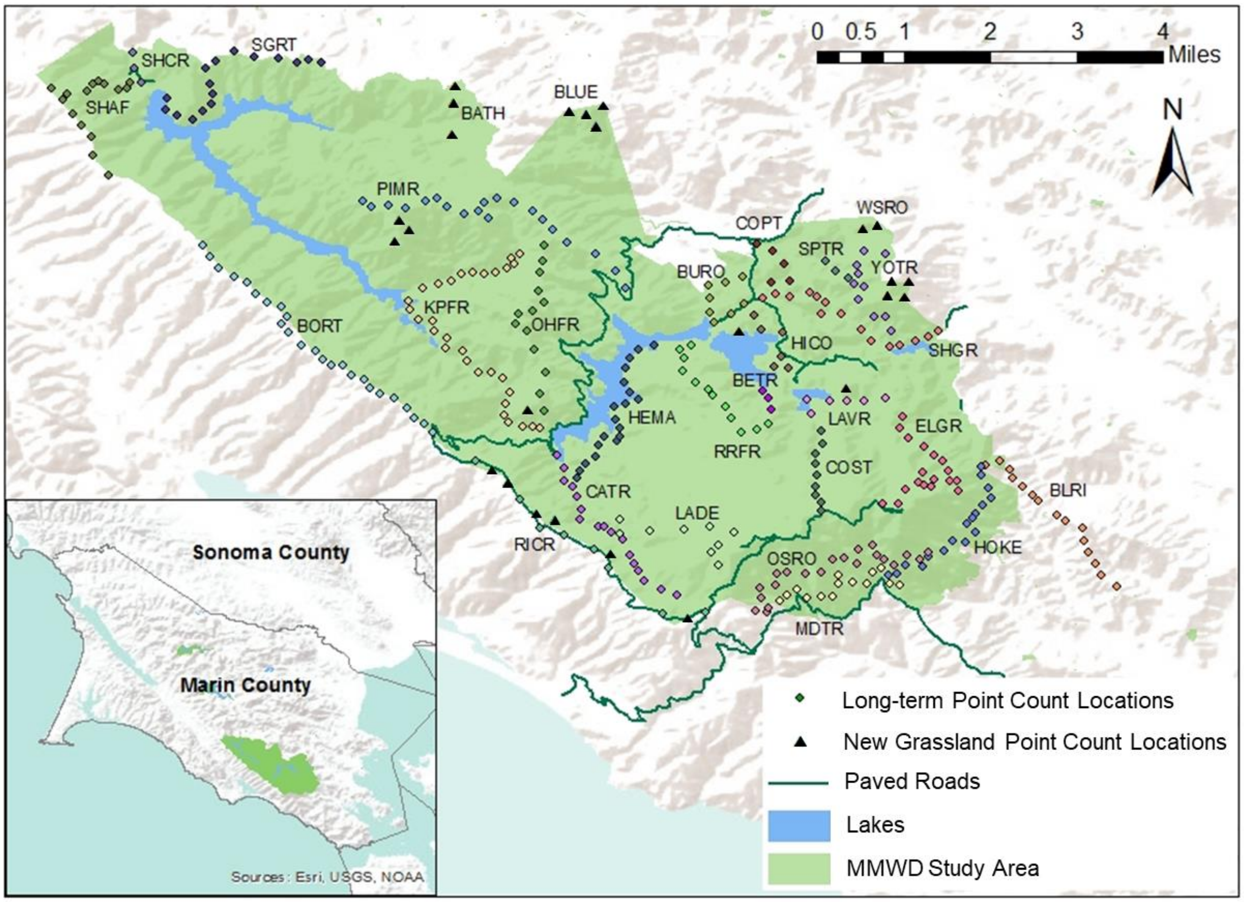

Figure 1. Map of 2019 point count locations conducted by Point Blue Conservation Science in the Marin Municipal Water District, Marin County, California. On top of the long-term point count stations (n=337) that are the focus of this report, also shown are the new grassland point count stations (n=25) established in 2019 that are summarized in a separate report (DiGaudio and Humple 2019). For the long-term points, each transect is represented by a different color.

Data Management

All 2019 data were entered online. All years of data can be accessed at the password protected California Avian Data Center (CADC; http://data.prbo.org/cadc2/) by Point Blue staff and by

MMWD staff upon password request. CADC is a node of the Avian Knowledge Network (AKN), whose goal is to share observational bird data with as wide an audience as possible, while assuring data quality, validity, and metadata documentation, and simultaneously respecting the rights of data contributors and resource managers. All users of any AKN dataset are instructed to acknowledge the contribution of the data contributors. Each data set contributed to the AKN has an associated level of access to that data that can allow or restrict access (Ballard et al. 2008). The landbird data for the MMWD, post data-validation by a Point Blue data manager or project leader, is made available at a moderate level (Level 3, from 1-5). Level 3 availability allows the data to broadly be included with regional or national summaries of bird data (e.g., available for meta-analyses and range-wide maps and graphs). At the same time, it requires researchers or members of the public to request permission to access the detailed dataset itself, which will allow its uses to be tracked; Point Blue staff will receive any data requests, and share those requests with MMWD staff. This level was determined based on the interests of the MMWD, and the Data Availability Level can be increased or decreased at any time.

Personnel

Point Blue staff biologists trained in the songs and calls of the birds of the MMWD study area conducted all surveys in 2019. They were Hilary Allen, Renée Cormier, Mark Dettling, Ryan DiGaudio, Megan Elrod, and Diana Humple.

Statistical Analysis

We included data from 1996, 1997, 1998, 2001, 2004, 2007, 2010, 2013, 2016 and 2019. Data from 1999 were excluded because sites surveyed were not consistent with other years. Of the 337 points surveyed each year, two points (SGTR 16 and SHGR 15) were dropped from analysis because they were not surveyed in all years.

We analyzed individual species, excluding all waterbirds (e.g., ducks, herons, coots, grebes), shorebirds, owls, non-breeding migratory species (e.g., Ruby-crowned Kinglets, Fox Sparrows), and species not well sampled with the point count method such as non-territorial species, flocking species, and species with very large territories (e.g., swallows, ravens, crows, raptors; see Appendix B for common and scientific names of all species mentioned in this report). We also excluded species detected infrequently, including some species for which no individuals were detected in some years: American Goldfinch, Black Phoebe, Black-headed Grosbeak, Blue Grosbeak, Brewer's Blackbird, Brown-headed Cowbird, California Thrasher, Cassin's Vireo, Chipping Sparrow, European Starling, Lark Sparrow, Lazuli Bunting, Lesser Goldfinch, Nuttall's Woodpecker, Pine Siskin, Pygmy Nuthatch, Western Bluebird, Western Wood Pewee, and White-breasted Nuthatch. We excluded Allen's Hummingbirds because it is not possible to visually distinguish most individual Allen's Hummingbirds from their close relative the Rufous

Hummingbird (a migrant bird that does not breed in Marin County, but is present during the survey period). We only analyzed data from 2004 to 2019 for Swainson's and Hermit thrushes because we suspect that one observer who conducted surveys during the earlier years of the study was not always distinguishing these species accurately.

We used data from two visits for each year. In 1997, three surveys were conducted, so we eliminated all data from one of the three visits for each transect; we excluded whichever visit (the first or third) was an outlier when compared to dates the same transect was surveyed in all other years.

Table 1. Long-term point count transects conducted by Point Blue Conservation Science in 2019 in the Marin Municipal Water District. Additional surveys conducted in MMWD grasslands in 2019 are included a separate report (DiGaudio and Humple 2019).

Transect Name	Transect Code	No. of Points
Berry/Bon Tempe Trail	BETR	3
Blithedale Ridge Road	BLRI	15
Bolinas Ridge Trail	BORT	25
Bull Frog/Bon Tempe Road	BURO	8
Cataract Trail	CATR	17
Colier Springs Trail	COST	9
Concrete Pipe Trail	COPT	5
Eldridge Grade	ELGR	18
Helen Mark Trail	HEMA	19
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
Ridgecrest Blvd.	RICR	8
Rocky Ridge/Lagunitas-Rock Spring Road	RRFR	12
San Geronimo Ridge Trail	SGRT	16
Shafter Grade/Peter's Dam	SHAF	15
Shafter Creek	SHCR	3
Shaver Grade	SHGR	15
Six Points Trail	SPTR	3
Yolanda Trail	YOTR	10
Total		337

We calculated the mean number of detections within 50 m for each species and year by averaging across all points, producing an index of abundance. This gave us one per-point-per-visit abundance value for each species during each year of the study. To summarize the detections at each point, we averaged the number of detections within 50 m of each point for each species for the two visits at each point in a year. There were a few points (9 in 1996, 7 in 2001) that were only surveyed once in a given year, so the number of detections on that single visit was used in place of the average.

To evaluate the trend over time, we used natural log transformation on the abundance values and used linear regression to describe the relationship between species abundance and year, such that the slope (β) of this line represented the annual change in the number of detections. We used $\alpha = 0.05$ to evaluate if the slope was statistically different from 0. We also discuss species for which the P-value for the slope was between 0.05 and 0.1, as these trends may be biologically significant, and we refer to these as marginally significant.

Data cleaning and analysis were done in R version 3.6.1 (R Development Core Team 2019).

To compare results from the MMWD dataset to larger-scale trends in bird abundance, we used trends estimated from the Breeding Bird Survey (BBS) for all of California (Sauer et al. 2018). We looked at BBS linear regression trend results over two temporal scales: the core BBS dataset from 1970 to 2017, and from 1996 to 2017, which represented a time period that most closely matched our study (https://www.mbr-pwrc.usgs.gov/; Sauer et al. 2018). Because BBS data was only available through 2017, this period did not exactly match our monitoring window. The results from the BBS trends estimates are presented with a 95% credible interval (CI). Because credible intervals are similar to confidence intervals, we assumed that if the 95% CI did not include zero, the trend was statistically significant in a manner that was comparable to our MMWD trends that were significant at $\alpha = 0.05$.

RESULTS

For 27 of the 41 (65.8%) species analyzed, there was little evidence ($P > 0.10$) that the trends were significantly different from zero (Figure 2 and Appendix C). For these species, we assume that populations are generally stable on the MMWD study area.

Four (9.8%) species showed statistically significant ($P \leq 0.05$) declines between 1996 and 2019 surveys: Ash-throated Flycatcher, California Scrub-Jay, California Towhee, and Downy Woodpecker (Figure 3 and Table 2). One (2.4%) additional species, Steller's Jay, showed a marginally significant ($P > 0.05$ and $P \leq 0.1$) decrease in abundance (Figure 3 and Table 2).

Five (12.2%) species exhibited significant (P $\leq$ 0.05) increases over the study period (Figure 4 and Table 2): Anna's Hummingbird, Hermit Thrush, Hermit Warbler, Olive-sided Flycatcher, and Wilson's Warbler. Four (9.8%) additional species showed marginally significant (P > 0.05 and P $\leq$ 0.1) increases in abundance: Audubon's (Yellow-rumped) Warbler, Black-throated Gray Warbler, Hairy Woodpecker, and Oak Titmouse (Figure 5 and Table 2).

The percent of species exhibiting declining trends (P $\leq$ 0.05) was much lower on MMWD lands compared to both time series of BBS data in California, and the percent of species with no evidence of a trend was much higher on MMWD lands (Table 2). However, among the 41 species analyzed, there were more species exhibiting increasing trends in the longer (1970-2017) BBS dataset compared to both the shorter BBS time series, and the MMWD dataset (Table 2).

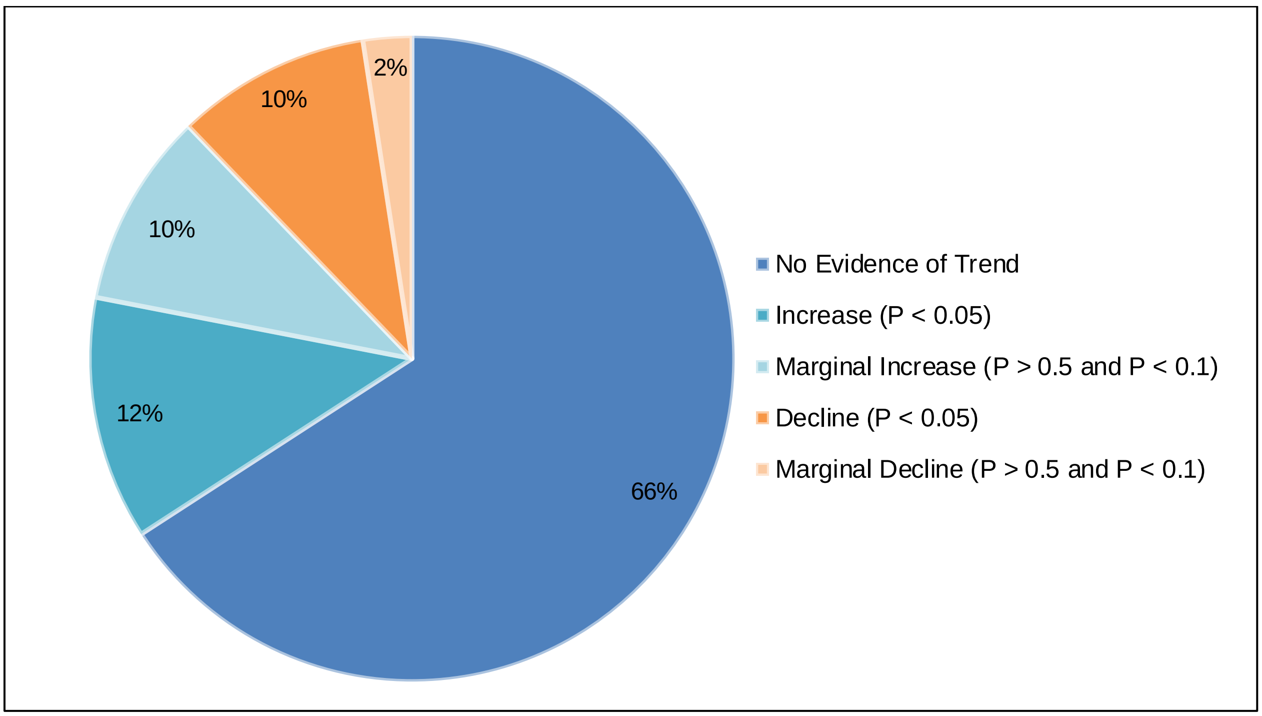

Figure 2. Percent of breeding landbird species included in analysis (n=41) that are increasing, marginally increasing, declining, marginally declining, or show no evidence of a trend in the Marin Municipal Water District from point count surveys conducted by Point Blue conservation Science, 1996-2019.

When comparing species with significant (P $\leq$ 0.05) trends on MMWD lands to state-wide trends in California across both time series, only one species (Anna's Hummingbird), was increasing in all three datasets, although Hairy Woodpecker showed a marginal increase on MMWD lands, and significant increases in the BBS datasets (Table 3). Olive-sided Flycatcher, and Wilson's Warbler were increasing on MMWD lands and decreasing in the BBS datasets, while Ash-throated Flycatcher and Downy Woodpecker were declining on MMWD lands and showed no evidence of a trend in the BBS datasets (Table 3). Hermit Thrush and Hermit Warbler were increasing on MMWD lands, with no evidence of a trend in the BBS dataset, while California Scrub-Jay and California Towhee showed similar patterns to one of the two BBS time series (Table 3). For species with marginal trends MMWD lands, some showed similar trends, opposite trends, or no trend in the BBS datasets; although we were not able to calculate BBS trends at a confidence interval comparable to the marginal trends on MMWD lands, like we could with the significant trends at P $\leq$ 0. 05.

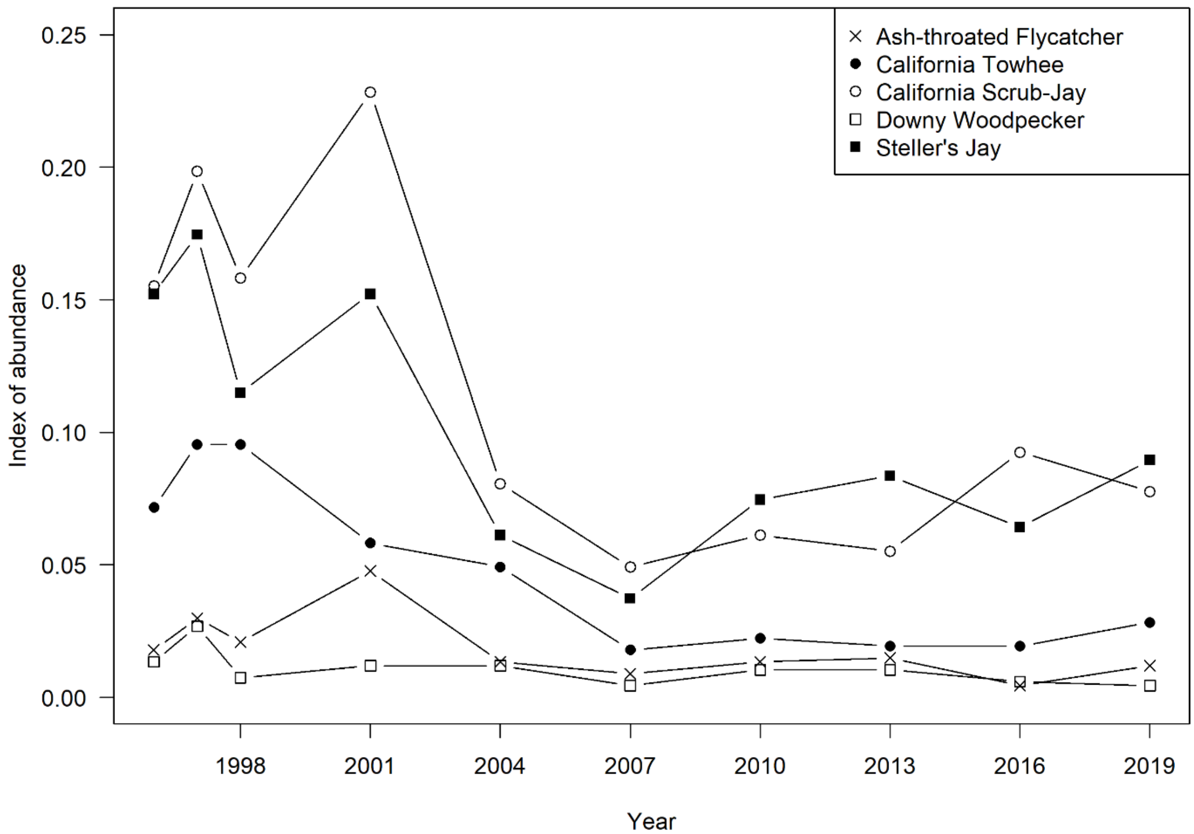

Figure 3. Mean abundance of birds within 50 m per point per visit of all declining species (Ash-throated Flycatcher, California Towhee, California Scrub-Jay, Downy Woodpecker, and Steller's Jay) from Point Blue Conservation Science point count surveys in the Marin Municipal Water District from 1996 to 2019. The Steller's Jay trend was marginally significant (P = 0.083), while the other four species were significant (P $\leq$ 0.05).

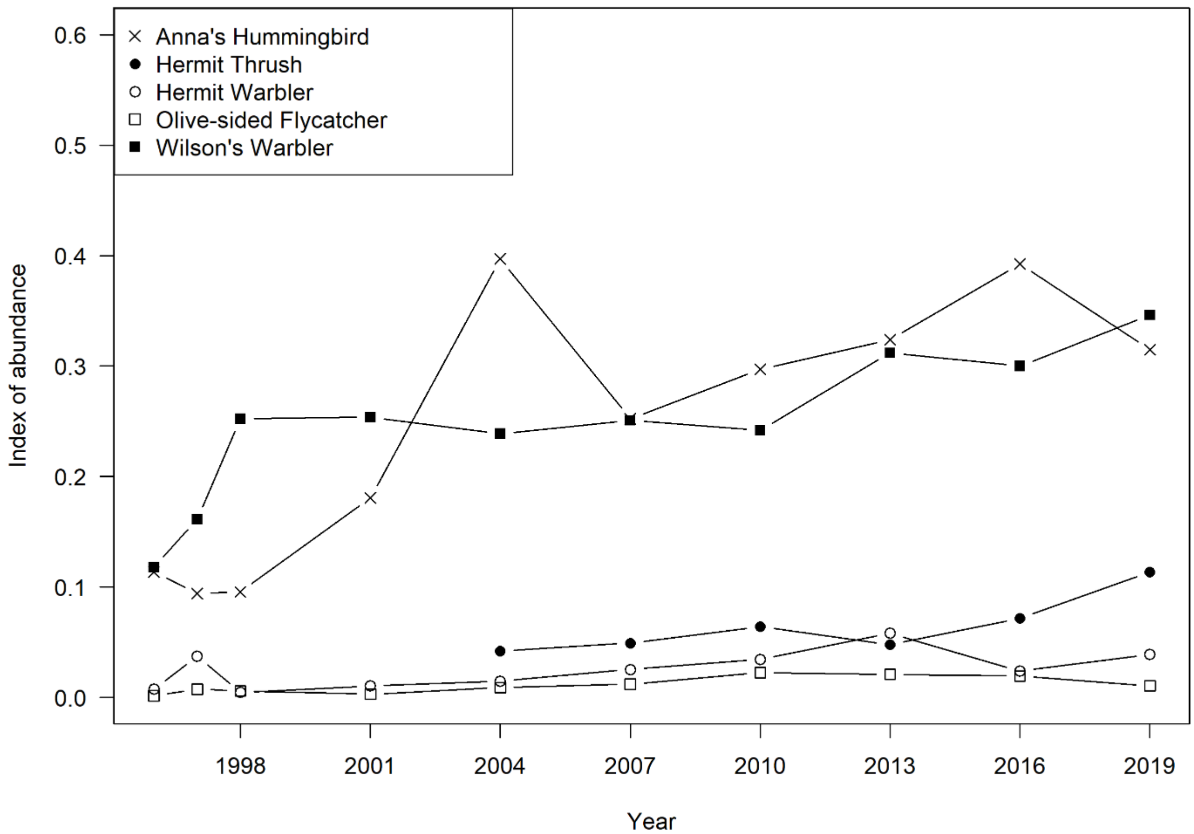

Figure 4. Mean abundance of birds within 50 m per point per visit of the five significantly-increasing species (P $\leq$ 0.05; Anna's Hummingbird, Hermit Thrush, Hermit Warbler, Olive-sided Flycatcher, and Wilson's Warbler) from Point Blue Conservation Science point count surveys in the Marin Municipal Water District from 1996 to 2019.

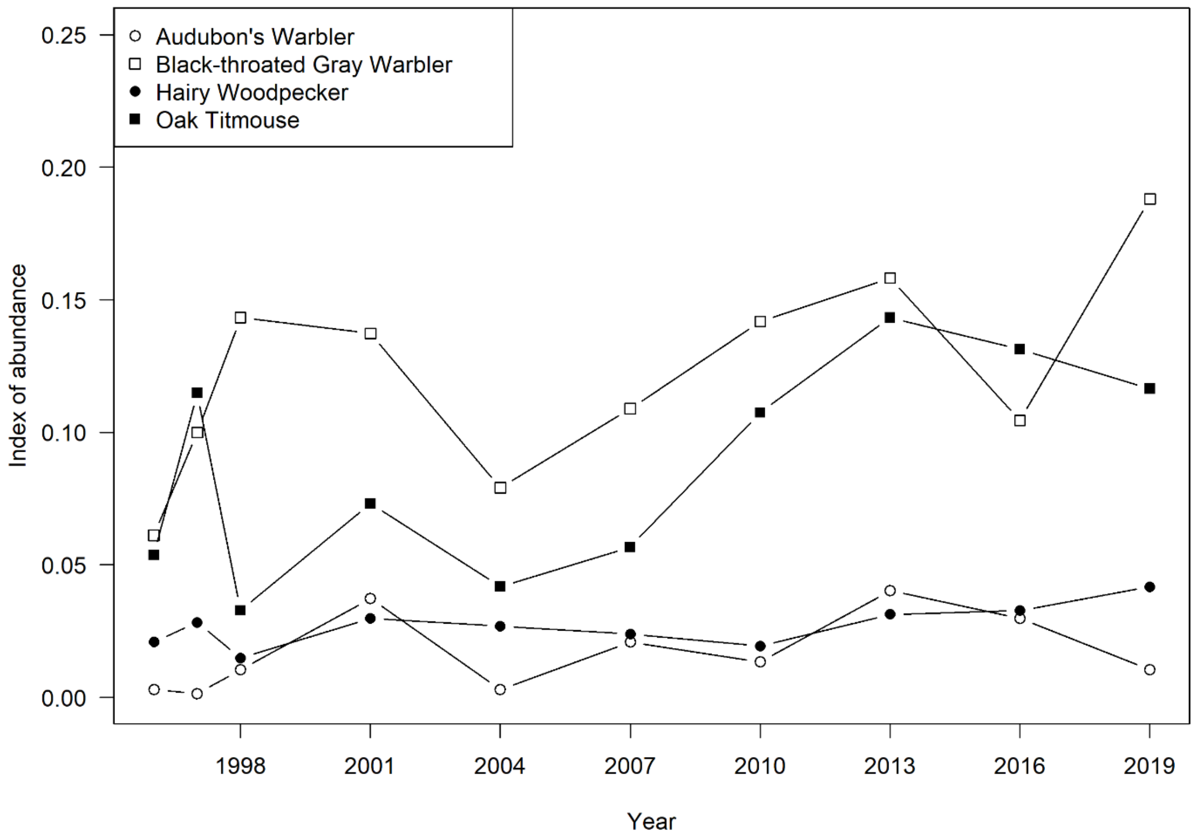

Figure 5. Mean abundance of birds within 50 m per point per visit of the four marginally increasing species (P > 0.05 and ≤ 0.1; Audubon's [Yellow-rumped] Warbler, Black-throated Gray Warbler, Hairy Woodpecker, and Oak Titmouse) from Point Blue Conservation Science point count surveys in the Marin Municipal Water District from 1996 to 2019.

Table 2. Percent of species with an increasing trend, decreasing trend, or no evidence of a trend at two significance values (P ≤ 0.1) and (P ≤ 0.05) for the 41 species of landbirds included in the trend analysis for the Marin Municipal Water District (MMWD) from point count surveys conducted by Point Blue Conservation Science, 1996-2019, compared to two time series of Breeding Bird Survey (BBS) data in California for the same species (Sauer et al. 2018). For the BBS data, species are considered declining or increasing if their 95% credible interval did not include zero; thus, BBS values in this table are comparable to the MMWD dataset where the trends are evaluated with P ≤ 0.05.

	MMWD (P ≤ 0.1) 1996 to 2019	MMWD (P ≤ 0.05) 1996 to 2019	BBS 1996 to 2017	BBS 1970 to 2017
% Declining	12.2	9.8	26.8	41.5
% Increasing	22.0	12.2	12.2	24.4
% No Evidence of Change	65.8	78.0	61.0	34.1

Table 3. Species with significant trend results from point count surveys conducted by Point Blue Conservation Science on Marin Municipal Water District (MMWD) lands compared to two time series of Breeding Bird Survey (BBS) data in California (Sauer et al. 2018), for the 41 species examined. Direction of trend shown as ↑ (increasing) or ↓ (declining). For MMWD surveys, those with significant trends ($P \leq 0.05$) are shown without parenthesis and those with marginally-significant trends ($0.5 < P \leq 0.1$) in parenthesis. BBS trends were considered positive or negative if the 95% credible interval did not include 0; thus, BBS trends presented here are more similar to the MMWD dataset where trends are evaluated at $P \leq 0.05$.

Species	MMWD 1996 to 2019	BBS 1996 to 2017	BBS 1970 to 2017
Anna's Hummingbird	↑	↑	↑
Audubon's (Yellow-rumped) Warbler	(↑)	no trend	↑
Black-throated Gray Warbler	(↑)	↓	↓
Hairy Woodpecker	(↑)	↑	↑
Hermit Thrush	↑	no trend	no trend
Hermit Warbler	↑	no trend	no trend
Oak Titmouse	(↑)	↓	↓
Olive-sided Flycatcher	↑	↓	↓
Wilson's Warbler	↑	↓	↓
Ash-throated Flycatcher	↓	no trend	no trend
California Scrub-Jay	↓	↓	no trend
California Towhee	↓	no trend	↓
Downy Woodpecker	↓	no trend	no trend
Steller's Jay	(↓)	no trend	no trend

DISCUSSION

Based on monitoring results from 1996 to 2019 for the 41 species selected for analysis, we found that 36 (88%) of the species either showed no evidence of a trend (66%), or exhibited increasing trends (12%) or marginally increasing trends (10%) in abundance. Of the remaining 5 (12%) species, 4 exhibited significantly declining trends, while one other declining trend was marginally significant. These results are similar to our previous analysis of the 1996 to 2016 MMWD data (Cormier and Humple 2017) when we found 86% of species were either increasing or showed no evidence of trend, and 14% of species with declining and marginally-declining trends.

Compared to state-wide trends from Breeding Bird Survey data, more species on MMWD lands showed no evidence of a trend and there were fewer species with declining trends than both the similar time series and longer time series of state-wide data. Interestingly, the longer BBS dataset had twice as many species with increasing trends than both the shorter BBS dataset, and the MMWD dataset ($P \leq 0.05$); compared to the shorter BBS dataset, the longer BBS dataset also had nearly twice as many species with decreasing trends, and fewer birds with no trend.

Three of the four species with significant declines in this analysis (California Scrub-Jay, California Towhee, and Ash-throated Flycatcher) have shown declines in previous analyses of MMWD data, as did the marginally-significant declining Steller's Jay (Cormier and Humple 2017, Cormier et al. 2014). The Downy Woodpecker is new to the list. The Downy Woodpecker, Ash-throated Flycatcher, and Steller's Jay (marginally declining in the MMWD) all show no evidence of a trend from BBS datasets. The California Scrub-Jay and the California Towhee were both declining in one of the two time series in California (Sauer et al. 2018).

It is possible that these declining species are responding to changes in local conditions, such as changes in food availability, habitat, or climate. For example, Sudden Oak Death Syndrome (SODS; *Phytophthora ramorum*) has caused mortality of many oak (*Quercus* sp.) and tanoak (*Notholithocarpus densiflorus*) trees in Marin County during the study period (McPherson et al. 2005), which has resulted in changes in the relative abundance of these tree species, and, in some cases, dramatic changes to the structure of the forests on MMWD lands. Additionally, the acorns provided by these species are an important food source for jays, particularly during winter (Greene et al. 1998, Curry et al. 2002). While SODS is impacting forests throughout California, some areas are more impacted than others (UC Berkeley Forest Pathology and Mycology Lab 2020), and declines in California Scrub-Jays and Steller's Jays – both year-round residents in Marin – may be impacted by this disease. However, if the decline in acorns were the sole cause of decline of the jay species, we would have expected declines in Acorn Woodpeckers, who also rely on this food source, but this species has been stable over the course of the study. Therefore, if SODS is causing the decline in jays, it has not affected all bird species associated with acorns in the same way.

West Nile Virus (WNV, *Flaviviridae*, *Flavivirus* spp.) is another possible factor for declines in the two jay species. WNV was first isolated in California in 2003 (Reisen et al. 2004; LaDeau et al. 2007). While Marin County has never had a relatively high incidence of WNV, and the last positive case in the county documented in a bird was in 2017 (California West Nile Virus Website 2020), corvids (e.g., jays) are particularly susceptible to the disease (Wheeler et al. 2009, Koenig et al. 2007).

The Downy Woodpecker and Ash-throated Flycatcher were both declining on MMWD lands, and not in the BBS datasets (Sauer et al. 2018). For the Downy Woodpecker, we do not know why they would be declining on MMWD lands. They tend to be found in riparian and moist mixed evergreen forests, while the Hairy Woodpecker, which is increasing in all three datasets and has been more abundant overall in the MMWD dataset, is associated with conifer, and mixed conifer habitats, but is also found in the moist mixed evergreen forests and riparian thickets in Marin County (Shuford 1993). It is possible that habitat succession has created conditions more favorable to the Hairy Woodpecker on MMWD lands, and/or there may be some competition between the two species (e.g., Leighton et al. 2018).

Habitat conversion from shrub to forest along the central coast of California has been documented, with possible causes including conifer encroachment resulting from fire suppression and other factors, combined with climatic variables (Hsu et al. 2012). The Landsat imagery shown in that document suggests this change is occurring within the MMWD lands as well. This may account for some of the changes we observed, such as declines in shrub-associated species California Scrub-Jay and California Towhee, and species like Ash-throated Flycatcher that tend to be associated with more open forest habitats and chaparral edge (Shuford 1993). At the same time, several forest-associated species that showed increasing trends may be responding positively to this change it habitats, such as all of the warbler species with increasing trends, and the Hermit Thrush.

The Ash-throated Flycatcher is a migratory species, and declines we observed may also be driven by changes (e.g., habitat, climate) during parts of their annual cycle when they are not in Marin County (Small-Lorenz et al. 2013). Additionally, widespread declines in aerial insectivores have been documented (Nebel et al. 2010), which may also be impacting the Ash-throated Flycatchers that breed locally. However, there are other aerial insectivores that breed on MMWD lands that are not declining (e.g., Olive-sided Flycatcher, Pacific-slope Flycatcher), so if a decline in food availability is the cause, it is possible that they are not foraging on the same species of insects as the other flycatchers that breed in Marin, or the three species overwinter and/or migrate to different areas, and are not facing the same challenges when they are not in Marin County.

Among the species that were increasing, Anna's Hummingbird was increasing on MMWD lands and both California datasets. Anna's Hummingbirds have been shown to increase with an increase in food sources, such as flowering plants and feeders (Russell 1996, Wethington and Russell 2003), and have even been undergoing a range expansion in the northern part of their range that appears driven in part by human-provided nectar feeders (Greig et al. 2017); it is possible that there has also been an increase in food in Marin County, if residents of the county are planting more flowering plants, and/or putting out hummingbird feeders.

Four species (Olive-sided Flycatcher, Wilson's Warbler, Oak Titmouse, and Black-throated Gray Warbler, with the latter two marginally-significant) were increasing on MMWD lands but declining in both BBS datasets. Hermit Thrush and Hermit Warbler were both increasing on MMWD lands, and showed no evidence of a trend in the BBS data. Audubon's Warbler (a subspecies of Yellow-rumped Warbler) showed a marginally-significant increase on MMWD lands, and also showed an increasing trend in the longer BBS time series. The increasing trend for Olive-sided Flycatcher is particularly encouraging, as it is a California Bird Species of Special Concern (Shuford and Gardali 2008) that shows a declining trend on BBS surveys in California (Sauer et al. 2018) and in riparian habitat elsewhere in the region (Humple and Porzig 2012, Dettling et al. *in prep.*). Changes in vegetation structure as a result of SODS, noted above, may also explain some of the increasing trends for some species. For example, Olive-sided Flycatchers have been positively associated with disturbance and fire (Bock and Lynch 1970, Fontaine et al. 2009) and other forest-openings (Altman and Sallabanks 2012). It is possible that the many forest openings caused by SODS on MMWD lands has had a positive effect on Olive-sided Flycatcher. This may also explain the differing pattern between Olive-sided Flycatchers in forests on MMWD lands compared to the declines observed in Marin County NPS riparian habitat (Humple and Porzig 2012; Dettling et al. *in prep*).

This pattern of stable or increasing populations of landbirds on MMWD lands is promising, particularly when many of these are undergoing declines at larger spatial scales or in other areas (Rosenberg et al. 2019). For example, Oregon (subspecies of Dark-eyed) Junco, Warbling Vireo, Purple Finch, and Wrentit are all common species detected during MMWD landbird surveys that currently show no evidence of a trend MMWD lands (Appendix C), but are declining in both of the BBS time series that we evaluated (Sauer et al. 2018).

There is a growing body of knowledge that predicts climate change will, either independently or together with other threats, exacerbate changes in landbird populations (Tingley et al. 2009, Jongsomjit et al. 2013). Given this prediction, effective land stewardship will be augmented by being able to effectively detect changes in natural resources. The long-term landbird dataset from MMWD monitoring has played an important role in our understanding of local landbird populations, including in the One Tam region (Edson et al. 2016); and currently, this dataset has been proposed to be used for the Marin County Compass project, a new performance management program in the County of Marin where the landbird data would be one of the metrics of ecological health for the County, if selected.

Our results show that although many landbird species are declining in California, most species on MMWD lands are either stable or increasing. This suggests that the extensive amount of diverse and protected habitat types on MMWD lands are important to landbirds, and likely to other species that also depend on these lands. Continued monitoring of the avifauna of MMWD will keep track of the status of the collective and individual species and provide information needed for land managers to understand how this natural resource is doing and determine if management action is warranted.

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APPENDICES

Appendix A. Date of all long-term point count surveys conducted by Point Blue Conservation Science in the Marin Municipal Water District in 2019. Dates for new grassland point surveys can be found in DiGaudio and Humple (2019).

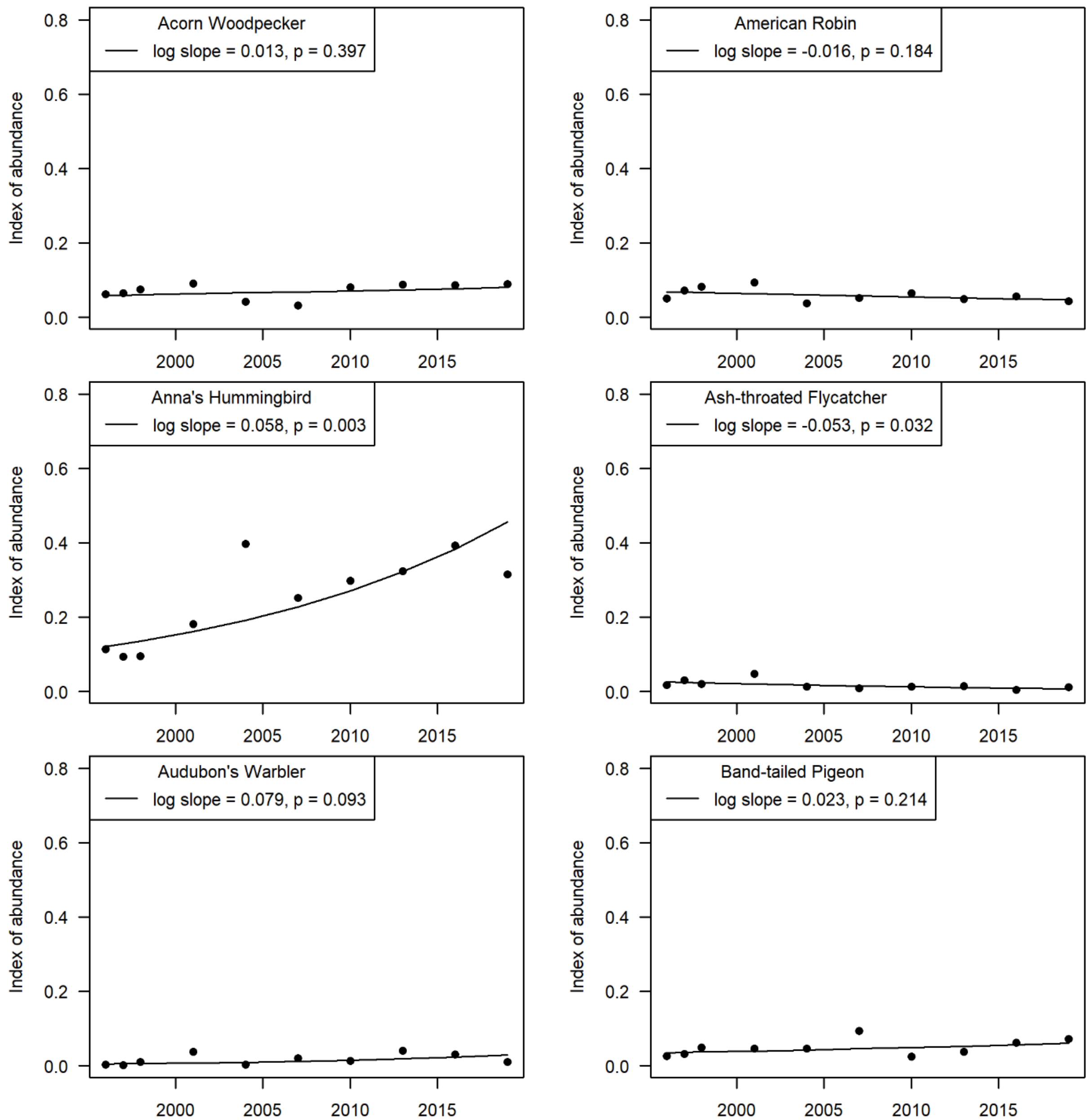
Transect	Code	Visit 1	Visit 2
Berry/Bon Tempe Trail	BETR	22-May	19-June
Blithedale Ridge Road	BLRI	27-May	13-June
Bolinas Ridge Trail	BORT	28-May	17-June
Bull Frog/Bon Tempe Road	BURO	22-May	11-June
Cataract Trail	CATR	22-May	12-June
Colier Springs Trail	COST	24 & 29-May	17-June
Concrete Pipe Trail	COPT	10-May	13-June
Eldridge Grade	ELGR	14-May	11-June
Helen Mark Trail	HEMA	17-May	14-June
Hidden Cove/Pine Point	HICO	22-May	11-June
Hoo-Koo-E-Koo Road	HOKE	9-May	10-June
Kent Pump Road	KPFR	13-May	12 & 20-June
Laurel Dell/ Lagunitas-Rock Spring Road	LADE	4-May	13-June
Lakeview Road	LAVR	24-May	17-June
Matt Davis Trail	MDTR	8-May	5-June
Oat Hill Road	OHFR	3-May	9 & 10-June
Old Stage Road	OSRO	30-May	17-June
Pine Mountain Road	PIMR	17 & 23-May	10 & 19-June
Ridgecrest Blvd.	RICR	23-May	12-June
Rocky Ridge/Lagunitas-Rock Spring Road	RRFR	22-May	19-June
San Geronimo Ridge Trail	SGRT	24 & 29-May	23-June
Shafter Grade/Peter's Dam	SHAF	23-May	18-June
Shafter Creek	SHCR	24-May	23-June
Shaver Grade	SHGR	10-May	14-June
Six Points Trail	SPTR	10-May	13-June
Yolanda Trail	YOTR	28-May	18-June

Appendix B. Common and scientific names of bird species detected during in the Marin Municipal Water District point count surveys conducted by Point Blue Conservation Science in 2019

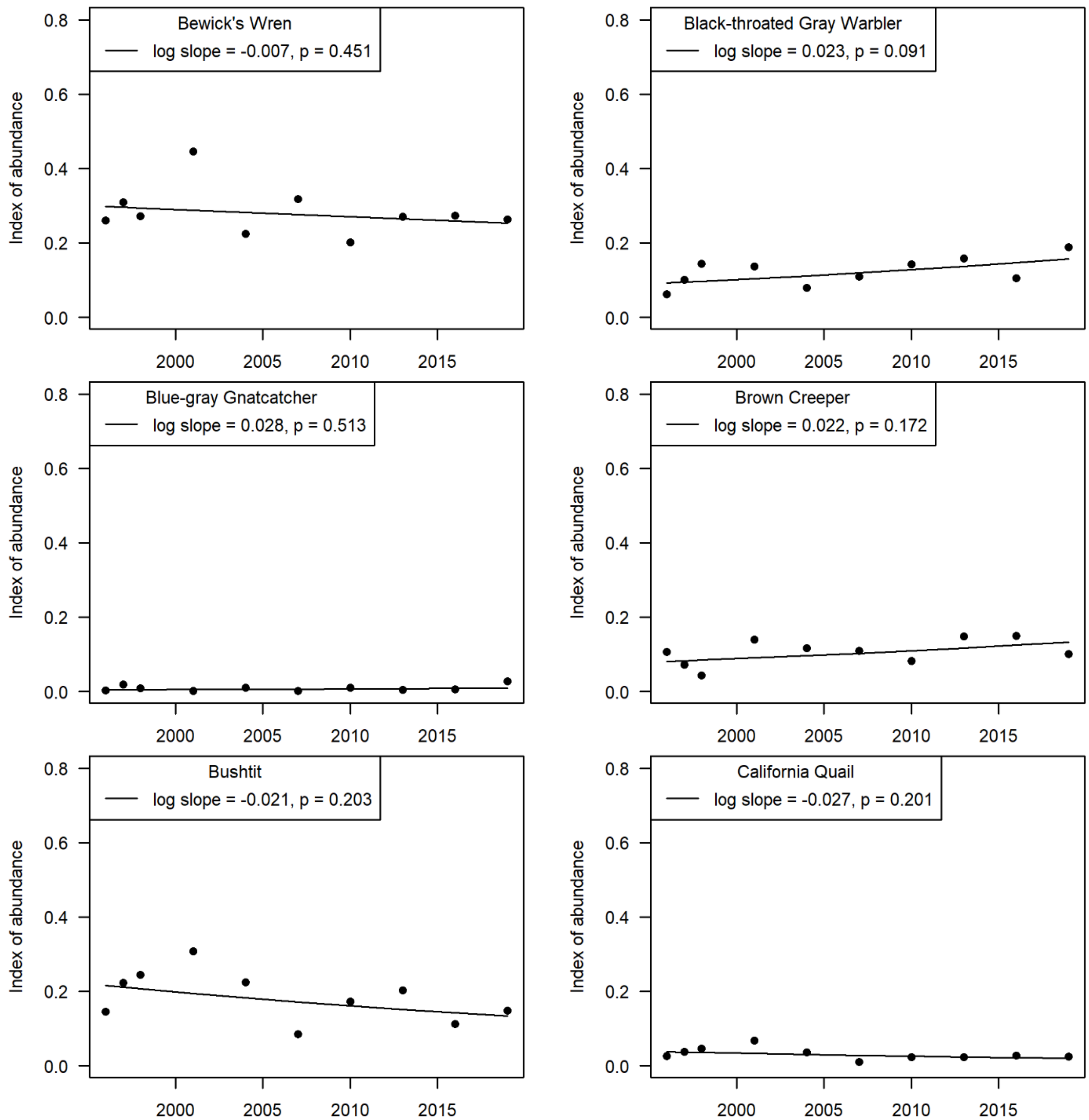
Common Name	Genus	Species
Acorn Woodpecker	*Melanerpes*	*formicivorus*
Allen's Hummingbird	*Selasphorus*	*sasin*
American Crow	*Corvus*	*brachyrhynchos*
American Robin	*Turdus*	*migratorius*
Anna's Hummingbird	*Calypte*	*anna*
Ash-throated Flycatcher	*Myiarchus*	*cinerascens*
Audubon's Warbler	*Setophaga*	*coronata auduboni*
Band-tailed Pigeon	*Patagioenas*	*fasciata*
Belted Kingfisher	*Megaceryle*	*alcyon*
Bewick's Wren	*Thryomanes*	*bewickii*
Black Phoebe	*Sayornis*	*nigricans*
Black-headed Grosbeak	*Pheucticus*	*melanocephalus*
Black-throated Gray Warbler	*Setophaga*	*nigrescens*
Blue-gray Gnatcatcher	*Polioptila*	*caerulea*
Brown Creeper	*Certhia*	*americana*
Brown-headed Cowbird	*Molothrus*	*ater*
Bullock's Oriole	*Icterus*	*bullockii*
Bushtit	*Psaltriparus*	*minimus*
California Quail	*Callipepla*	*californica*
California Scrub-Jay	*Aphelocoma*	*californica*
California Towhee	*Melozone*	*crissalis*
Canada Goose	*Branta*	*canadensis*
Caspian Tern	*Hydroprogne*	*caspia*
Cassin's Vireo	*Vireo*	*cassinii*
Cedar Waxwing	*Bombycilla*	*cedrorum*
Chestnut-backed Chickadee	*Poecile*	*rufescens*
Chipping Sparrow	*Spizella*	*passerina*
Common Merganser	*Mergus*	*merganser*
Common Raven	*Corvus*	*corax*
Cooper's Hawk	*Accipiter*	*cooperii*
Dark-eyed Junco	*Junco*	*hyemalis*
Double-crested Cormorant	*Phalacrocorax*	*auritus*
Downy Woodpecker	*Picoides*	*pubescens*
Eurasian Collared-Dove	*Streptopelia*	*decaocto*
European Starling	*Sturnus*	*vulgaris*
Golden-crowned Kinglet	*Regulus*	*satrapa*
Hairy Woodpecker	*Picoides*	*villosus*
Hermit Thrush	*Catharus*	*guttatus*
Hermit Warbler	*Setophaga*	*occidentalis*

Common Name	Genus	Species
House Finch	*Haemorhous*	*mexicanus*
House Wren	*Troglodytes*	*aedon*
Hutton's Vireo	*Vireo*	*huttoni*
Killdeer	*Charadrius*	*vociferus*
Lazuli Bunting	*Passerina*	*amoena*
Lesser Goldfinch	*Spinus*	*psaltria*
Mallard	*Anas*	*platyrhynchos*
Mourning Dove	*Zenaida*	*macroura*
Northern Flicker	*Colaptes*	*auratus*
Nuttall's Woodpecker	*Picoides*	*nuttallii*
Oak Titmouse	*Baeolophus*	*inornatus*
Olive-sided Flycatcher	*Contopus*	*cooperi*
Orange-crowned Warbler	*Oreothlypis*	*celata*
Osprey	*Pandion*	*haliaetus*
Pacific Wren	*Troglodytes*	*pacificus*
Pacific-slope Flycatcher	*Empidonax*	*difficilis*
Pileated Woodpecker	*Dryocopus*	*pileatus*
Pine Siskin	*Spinus*	*pinus*
Purple Finch	*Haemorhous*	*purpureus*
Purple Martin	*Progne*	*subis*
Pygmy Nuthatch	*Sitta*	*pygmaea*
Red Crossbill	*Loxia*	*curvirostra*
Red-breasted Nuthatch	*Sitta*	*canadensis*
Red-shouldered Hawk	*Buteo*	*lineatus*
Red-tailed Hawk	*Buteo*	*jamaicensis*
Red-winged Blackbird	*Agelaius*	*phoeniceus*
Rufous-crowned Sparrow	*Aimophila*	*ruficeps*
Sharp-shinned Hawk	*Accipiter*	*striatus*
Song Sparrow	*Melospiza*	*melodia*
Spotted Towhee	*Pipilo*	*maculatus*
Steller's Jay	*Cyanocitta*	*stelleri*
Swainson's Thrush	*Catharus*	*ustulatus*
Townsend's Warbler	*Setophaga*	*townsendi*
Tree Swallow	*Tachycineta*	*bicolor*
Turkey Vulture	*Cathartes*	*aura*
Violet-green Swallow	*Tachycineta*	*thalassina*
Warbling Vireo	*Vireo*	*gilvus*
Western Bluebird	*Sialia*	*mexicana*
Western Tanager	*Piranga*	*ludoviciana*

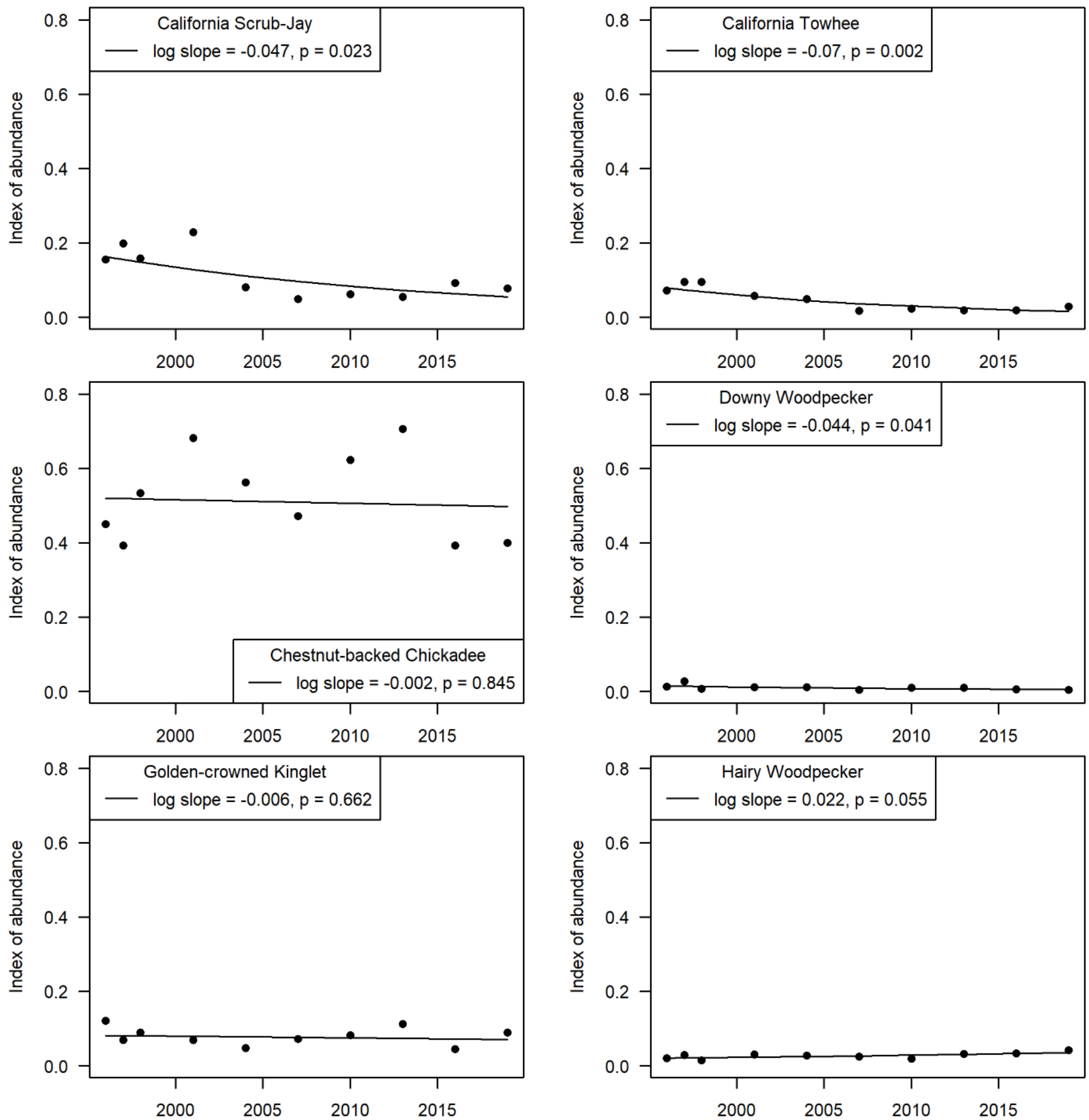
Appendix C. Trend results for 41 species of landbirds on Marin Municipal Water District lands (1996-2019), listed in alphabetical order.



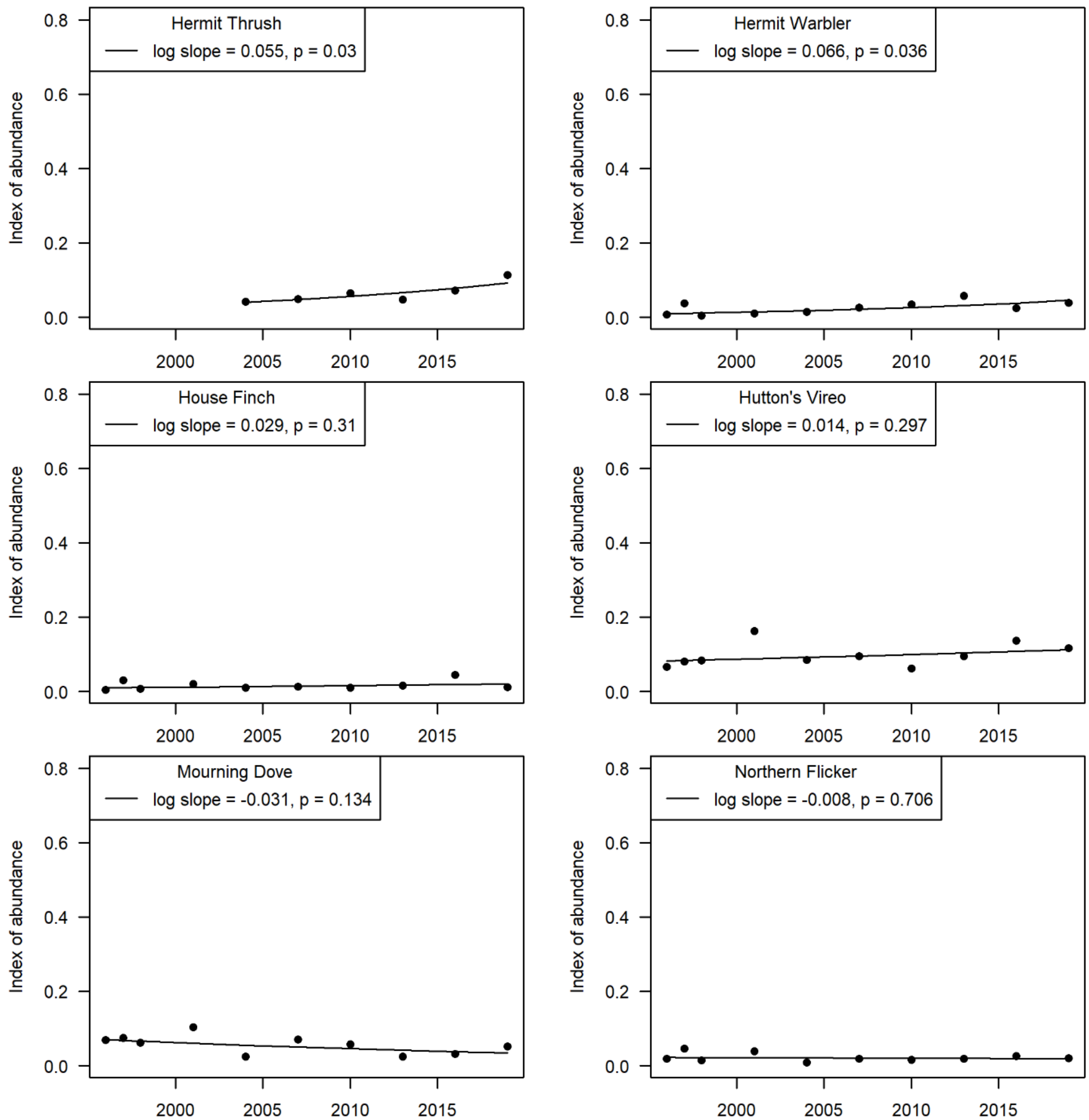
Appendix C (continued). Trend results for 41 species of landbirds on Marin Municipal Water District lands (1996-2019), listed in alphabetical order.



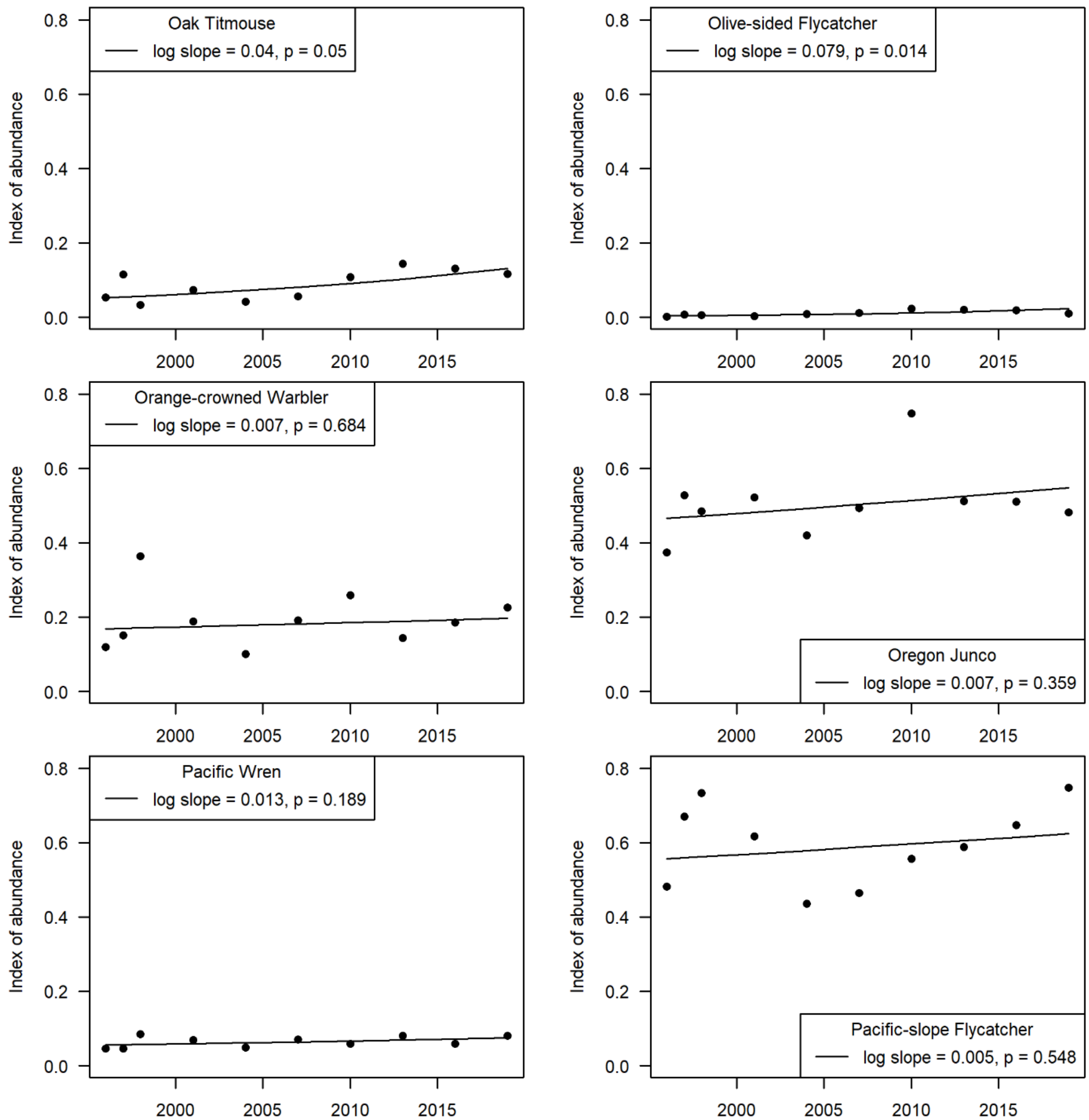
Appendix C (continued). Trend results for 41 species of landbirds on Marin Municipal Water District lands (1996-2019), listed in alphabetical order.



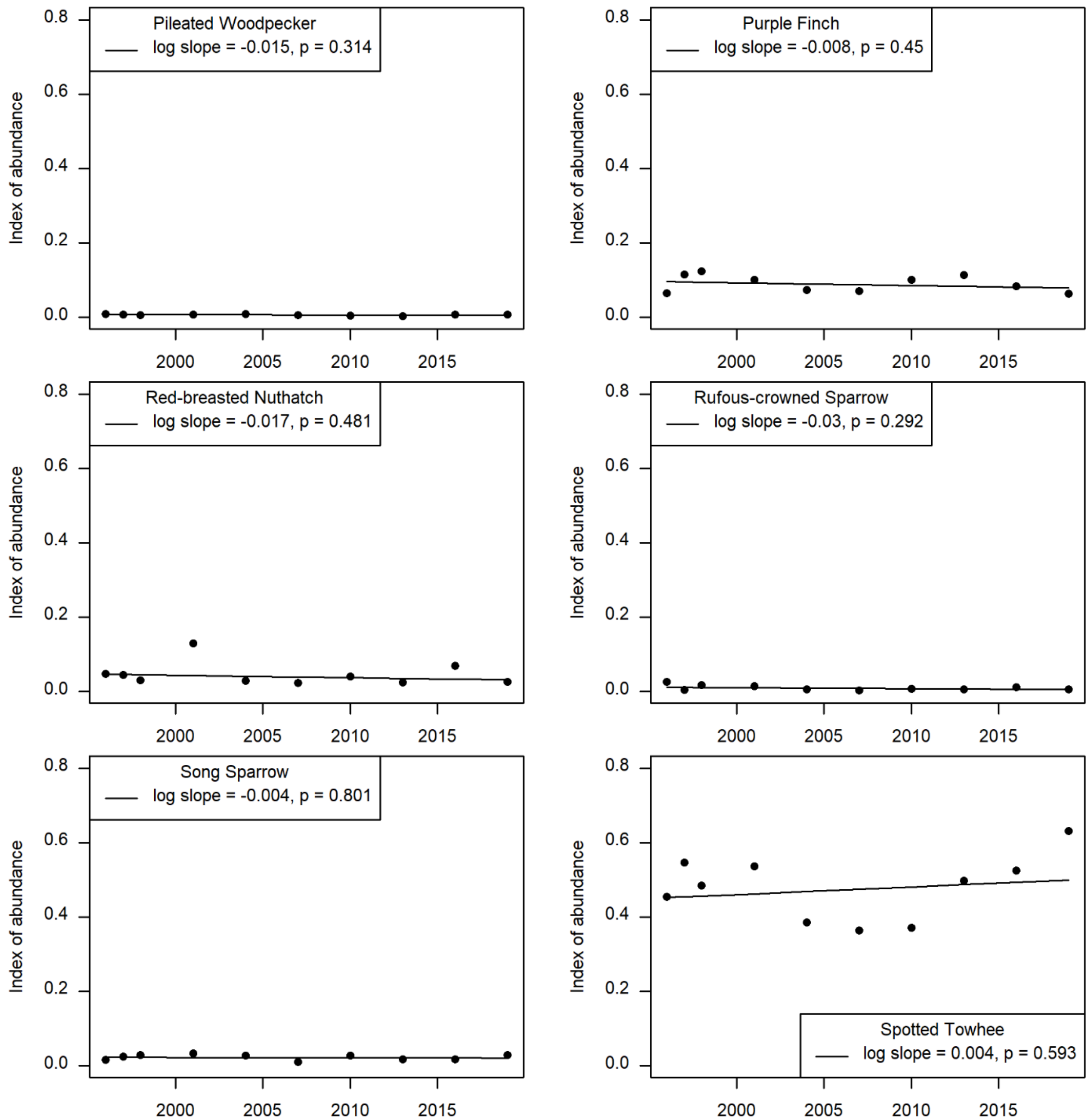
Appendix C (continued). Trend results for 41 species of landbirds on Marin Municipal Water District lands (1996-2019), listed in alphabetical order.



Appendix C (continued). Trend results for 41 species of landbirds on Marin Municipal Water District lands (1996-2019), listed in alphabetical order.



Appendix C (continued). Trend results for 41 species of landbirds on Marin Municipal Water District lands (1996-2019), listed in alphabetical order.



Appendix C (continued). Trend results for 41 species of landbirds on Marin Municipal Water District lands (1996-2019), listed in alphabetical order.