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Natural Resource Stewardship and Science

Riparian Landbird Monitoring in Golden Gate National Recreation Area and Point Reyes National Seashore

Analysis and Synthesis Report through Winter 2011-12

Natural Resource Technical Report NPS/SFAN/NRTR—2014/908

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ON THE COVER
Warbling Vireo
Artwork by: Sophie Webb

Riparian Landbird Monitoring in Golden Gate National Recreation Area and Point Reyes National Seashore

Analysis and Synthesis Report through Winter 2011-12

Natural Resource Technical Report NPS/SFAN/NRTR—2014/908

Diana L. Humple and Elizabeth L. Porzig

PRBO Conservation Science
3820 Cypress Dr. Suite 11
Petaluma, CA 94954

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Executive Summary

This document constitutes an analysis and synthesis report for landbird (passerines and near-passerines) monitoring conducted in riparian habitats in Point Reyes National Seashore and Golden Gate National Recreation Area as part of the National Park Service's Inventory and Monitoring Program, and following protocols established for this purpose (Gardali et al. 2010).

Landbird monitoring has been conducted by PRBO Conservation Science (formerly Point Reyes Bird Observatory) at 14 riparian study sites intermittently since 1997, and is conducted annually at a subset of these study sites ("core" study sites). Monitoring was repeated at all sites in 2011, the first year of implementation of the comprehensive protocol (Gardali et al. 2010). Monitoring methods include point count surveys during the breeding season as well as mist netting during all seasons. Therefore, although 2011 was the first year of implementation of the comprehensive riparian landbird monitoring protocol at the full suite of sites, we were able to produce an analysis and synthesis report because of the historic data that PRBO has been collecting for years at these sites.

A separate and complementary progress report provides more information on the monitoring efforts conducted in 2011, including basic summary results and a summary of the activities conducted that year (Jennings and Humple 2014). That information is not repeated herein.

One primary objective of this analysis and synthesis report was to identify a list of focal species for use in analyses herein and in future reports. We selected focal species based on a variety of resources, including California Partners in Flight focal species, California Bird Species of Special Concern (Shuford and Gardali 2008), climate change vulnerable species (Gardali et al. 2012), and Palomarin study species; as well as expert opinion and the availability of sufficient data. Twenty-five focal species were selected, including 10 year-round residents, nine Neotropical migrants, five overwintering species, and one passage migrant. The most commonly-detected landbirds when looking at all riparian habitat in the parks combined include the year-round resident Song Sparrow (*Melospiza melodia*); Neotropical migrants Swainson's Thrush (*Catharus ustulatus*), Wilson's Warbler (*Cardellina pusilla*), and Allen's Hummingbird (*Selasphorus sasin*); and winter migrants Fox Sparrow (*Passerella iliaca*) and Ruby-crowned Kinglet (*Regulus calendula*).

The patterns in both point count and mist net data over this 11 year period (2001-2011) for these and the other focal species indicate predominantly stable populations. A few species showed trends, including increases (Wilson's Warbler and Purple Finch, *Haemorhous purpureus*) and declines (Olive-sided Flycatcher, *Contopus cooperi*; American Robin, *Turdus migratorius*; Ruby-crowned Kinglet; and Golden-crowned Sparrow, *Zonotrichia atricapilla*). A few other patterns were observed in the data although the trends were not statistically significant.

The collection of point count and mist netting data continues annually at the core sites, and 2014 is the next year planned for comprehensive point count surveys for the complete suite of study sites, following the protocol's recommendations to conduct surveys at all sites every three years.

Acknowledgments

We thank the National Park Service, and especially Point Reyes National Seashore and Golden Gate National Recreation Area and their staff, for support of this monitoring program. We are grateful to PRBO biologists S. Jennings, T. Gardali, S. Roberts, and R. Cormier for collecting point count data in 2011 (along with report authors), S. Jennings for project data management; numerous PRBO interns and banding supervisors, including R. Cormier and M. Dettling, for mist netting efforts; and T. Gardali for overseeing this project as PRBO's Pacific Coast and Central Valley Group Director. We thank Marin County Parks for their support of our monitoring effort at Pine Gulch Creek. We thank T. Gardali, D. George, M. Herzog, M. Koenen, D. Press, W. Merkle, S. Allen, and M. Denn for their contributions to the development and/or implementation of the riparian monitoring plan, N. Seavy for statistical advice, and T. Gardali and Michelle Gilbert for reviewing this report.

Introduction

In light of the widening influence of anthropogenic change on natural systems, monitoring of wildlife has become increasingly important. Long-term ecological monitoring enables managers to establish baselines for normality and identify populations in decline. Landbirds are recognized as indicators of changing ecosystems (Carignan and Villard 2002) and climate (MacMynowski et al. 2007). They are also relatively easy to monitor and allow for monitoring a suite of species representing diverse ecological requirements (Ralph et al. 1993, Hutto 1998). Finally, landbirds are an important natural resource, engendering a great deal of public interest. Several landbird species that occur regularly in the Point Reyes National Seashore (PORE) and Golden Gate National Recreation Area (GOGA) are State Species of Special Concern (Shuford and Gardali 2008) or California Partners in Flight Focal Species (http://www.prbo.org/calpif/plans.html).

PRBO Conservation Science has been monitoring landbirds in riparian habitat of PORE and GOGA since 1995 and at a suite of sites intermittently since 1997. These monitoring efforts were incorporated into the National Park Service's Inventory and Monitoring Program for the San Francisco Bay Area Network in a protocol for monitoring riparian landbirds in these parks (Gardali et al. 2010). The objectives of that protocol are to monitor trends in abundance, productivity, and survival of landbird populations in order to evaluate ecosystem health (i.e., provide early warning of resource change) and thereby inform managers when management actions are warranted and research is needed. A comprehensive monitoring program, utilizing multiple methods, can provide evidence for demographic mechanisms of population change and guide management practices (Porzig et al. 2011). Using more than one sampling technique can validate results and thus strengthen the degree of inference. By monitoring populations over long periods of time, we can separate biologically-relevant population trends from interannual variability, and therefore maximize investment of conservation and management efforts.

Full implementation of these protocols was first conducted in 2011. The separate and complementary Progress Report (Jennings and Humple 2014) provides a summary of the activities conducted and the data collected in 2011.

Although this was the first year of protocol implementation, because monitoring has occurred at some to all of these study sites each year since 1997, we were able to produce an analysis and synthesis report. Such reports are to be completed every six years and provide detailed analyses of population trends and/or another focused analysis. Based on fifteen years of monitoring, this report establishes a starting point in which to compare results from future riparian landbird monitoring analyses in PORE and GOGA.

Our objectives in this report are (1) to identify focal riparian landbird species to include in this and future analysis and synthesis reports; (2) to evaluate trends in indices of population abundance using two monitoring methods, mist-netting and point counting, for the established focal species; and (3) to estimate apparent survival rates for a subset of the focal species.

Methods

Detailed protocol for this monitoring project and additional site information can be found in Gardali et al. (2010), and methods for field work conducted in 2011 are described in Jennings and Humple (2014).

Study Sites

Monitoring was conducted at 14 established sites throughout PORE and GOGA (Figure 1). Sites were located within riparian areas (predominantly willow-alder), and all sites had been surveyed previously for inventory or prior monitoring purposes. These study sites were selected from a larger number of historically-surveyed sites based on habitat type and the existence of historic data, and include 185 points at 14 transects (Table 1). One site not occurring on National Park Service (NPS) lands was Pine Gulch, a riparian site on the Bolinas Lagoon Open Space Preserve on Marin County Open Space District (MCOSD) land that is included in the monitoring protocol (Gardali et al. 2010) and is a PRBO long-term riparian monitoring sites where both point counts and mist netting occur. PRBO also conducted point count surveys in non-riparian habitat at the Palomarin Field Station (Jennings and Humple 2014), and the results from that site are not included herein.

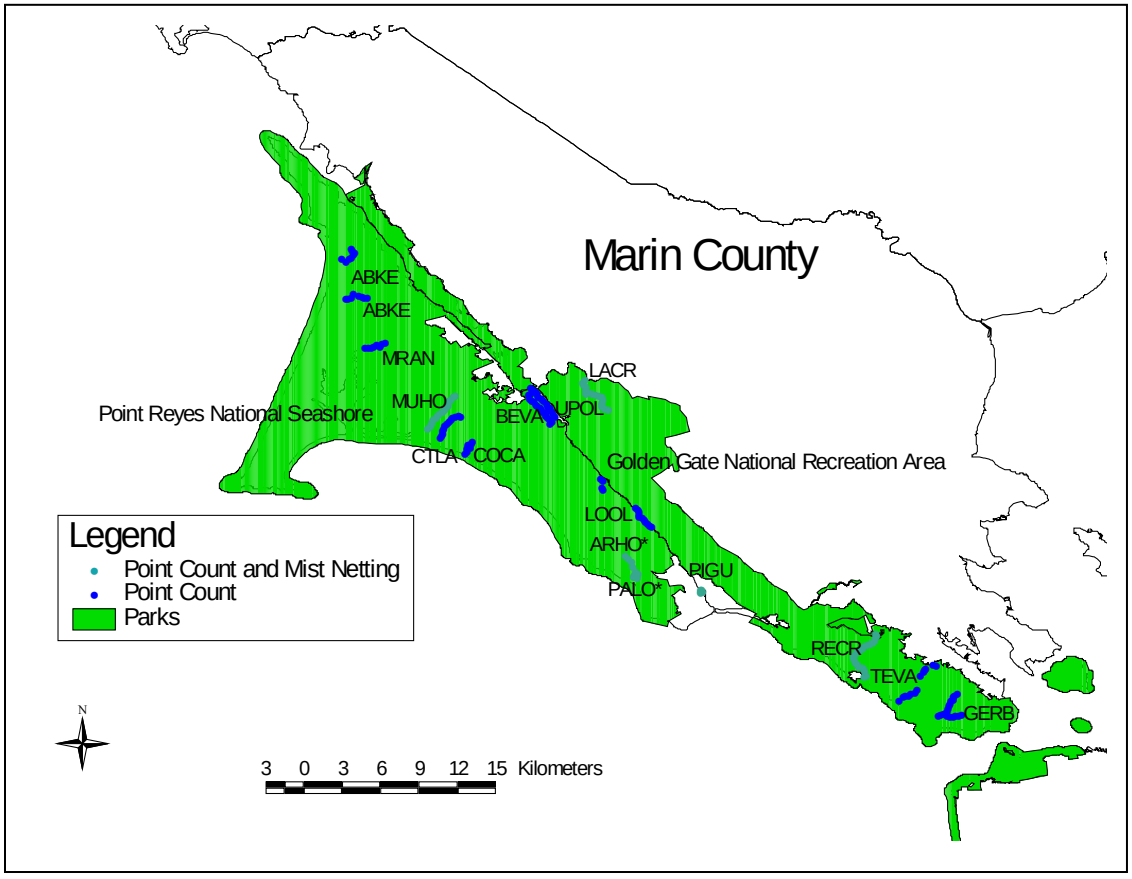


Figure 1. Locations of riparian point count and mist netting stations in PORE, GOGA, and MCOSD, Marin County, CA. Full site names are in Table 1. Also included for reference is the Palomarin Field Station (PALO). *Palomarin (PALO) is PRBO's primary intensive long-term monitoring site in the region but is not in riparian habitat.

Table 1. Riparian point count transects surveyed in PORE, GOGA, and MCOSD, including complete monitoring history, and point count survey protocol1 used in each year. This table is an updated version of Table 3 in Gardali et al. (2010); discrepancies are due to post hoc corrections made to assignment of protocols to historic data.

Transect	Code	# pts	# yrs surveyed[2]	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Abbott's / Kehoe	ABKE	16	3	A	A													C
Arroyo Honda	ARHO	7	15	A	A	A	A	B	C	C	C	C	C	C	C	C	C	C
Bear Valley	BEVA	16	3	A	A													C
Coast Camp	COCA	8	4	A	A	A												C
Coast Trail Laguna	CTLA	13	4	A	A				D									C
Gerbode Valley	GERB	18	4	A	A							C						C
Lagunitas Creek	LACR	18	15	A	A	A	A	B	C	C	C	C	C	C	C	C	C	C
Lower Olema Creek	LOOL	11	8	A	A				D	C	C	C	C					C
M Ranch	MRAN	8	3	A	A													C
Muddy Hollow	MUHO	15	14	A	A	A	A	B	C	C	C	C	C	C	C	C	C	C
Pine Gulch	PIGU	5	15	A	A	A	A	B	C	C	C	C	C	C	C	C	C	C
Redwood Creek[3]	RECR	24[3]	15	A	A	A	A	B	C	C	C	C	C	C	C	C	C	C
Tennessee Valley	TEVA	13	3	A	A													C
Upper Olema	UPOL	13	4	A	A							C						C
Total Points		**185**																

[1]Protocol Codes include:

A = FR50 (Fixed Radius): detections reported for birds <50m and >50m

B = VCP10_100: Detections were reported within bins (0-10m, 10-20m, 20-30m,30-40m, 40-50m, 50-60m, 60-70m, 70-80m, 80-90m, 90-100m)

C = VCP10_30: Detections were reported within bins (0-10m, 10-20m, 20-30m, 30-50m, 50-100m, 100+)

D = VCP25 Detections were reported within bins (0-10m, 10-20m, 20-30m,30-40m, 40-50m,50-75m, 75-100m, 100+)

[2] Within years 1997-2011; ARHO and COCA also had some point count surveys done <1997 that are not included herein (COCA in 1996, and ARHO for multiple years)

[3] Redwood Creek is divided into two continuous subtransects (Lower and Upper) that are surveyed separately.

Focal Species Selection

One of the primary objectives of this report, as the first riparian landbird analysis and synthesis report to be generated for PORE and GOGA, was to identify focal species to include in this and future analyses. We considered multiple criteria to come up with a list of riparian focal species. These species are intended to be included in future analysis and synthesis reports as well, although some changes may be desirable if more data for non-focal species become available, conservation concerns develop for other species, or monitoring objectives change.

We evaluated potential focal species based on multiple criteria (Table 2). This included their occurrence on the following lists: California Bird Species of Special Concern (Shuford and Gardali 2008); a climate vulnerability assessment recently completed for birds in California (Gardali et al. 2012); study species at PRBO's Palomarin Field Station; and focal species from California Partners in Flight (CalPIF) habitat conservation plans (RHJV 2000; and CalPIF 2002a, 2002b, 2004), especially the riparian bird conservation plan (RHJV 2000). Partners in Flight is a coalition dedicated to reversing declines in landbirds and whose mission emphasizes helping at-risk species and keeping common birds common; for each major habitat type in California, CalPIF focal species were selected so that together they reflect the various ecological processes and states of that habitat type, and so that focusing on these species will contribute to the conservation of the entire habitat type and benefit other species as well.

On top of the above lists, we also considered the expert opinion of the report authors as to riparian-associated species in the region. Finally, only species detected or captured with sufficient regularity in order to be able to conduct the analyses herein were selected as focal species (Table 2). We may have erred on the side of inclusion rather than exclusion, and were considering this focal species list for future analyses with additional years of data as well. The species with sufficient data differed among methods (point count or mist netting), seasons (breeding, fall, or winter; mist netting only), and analysis types (point count trend, mist netting trend, survival). Table 2 details which of these were selected for analysis for each of the 25 identified focal species.

Field Methods

Point Counts

In 2011, the first year of implementation of the full monitoring protocol, point counts were conducted at 14 riparian transects consisting of 185 point count stations. Additionally, from 1997 to 2010, point counts were conducted at some to all of these 14 transects each year (Table 1). All transects were surveyed in three years of the study (1997, 1998, and 2011) and will be sampled every three years in the future. Five transects (at the "core" study sites) consisting of 69 point count stations were surveyed annually from 1997 to 2011, and continue to be surveyed annually. Several of the remaining nine transects were surveyed in one or more additional years from 1999 to 2010 with an uneven sampling frequency across the transects; these surveys occurred as a result of various objectives and opportunities.

The Variable Circular Plot (VCP) protocol (SOP 6, Gardali et al. 2010) used for point count surveys from 2003-2011 involved recording individuals detected, by species, in the following distance

intervals from the observer standing at the point: 0-10 m, 10-20m, 20-30m, 30-50m, 50-100m, >100m, or as flyovers. From 1997 to 2002, a variety of other point count survey protocols were used, including the Fixed Radius method and other forms of VCP with different distance intervals (Table 1).

Table 2. Focal species for riparian landbird monitoring program in PORE and GOGA for use in point count (PC) trend, mist netting (MN) trend, and survival analyses in this 2012 report, and criteria used in their selection. Species are listed in taxonomic order according to Sibley (2000) and not American Ornithologists' Union (AOU) 2012. See Appendix A for scientific names.

Species	Spp Code	Migratory Status in PORE & GOGA[1]	CalPIF Focal Spp[5]	CA BSSC[6]	CA Climate Change Vulnerable[7]	PRBO Palomarin Study Spp	PRBO Expert opinion	Sufficient PC or MN Data	PC Trend Focal Spp	MN Trend Focal Spp[9]	Survival Focal Spp
Downy Woodpecker	DOWO	R					X	PC	X		
Allen's Hummingbird	ALHU	N					X	MN[8]		S	
Olive-sided Flycatcher	OSFL	N	X	X			X	PC	X		
Western Wood-Pewee	WEWP	N					X	PC	X		
Pacific-Slope Flycatcher	PSFL	N					X	PC/MN	X	S,F	
Warbling Vireo	WAVI	N	X				X	PC/MN	X	S,F	
Western Scrub-Jay	WESJ	R	X			X	X	PC	X		
Chestnut-backed Chickadee	CBCH	R					X	PC/MN	X	S,F,W	
Bewick's Wren	BEWR	R					X	PC	X		
Wrentit	WREN	R	X			X	X	PC/MN	X	S,F	X
Ruby-crowned Kinglet	RCKI	W					X	MN		F,W	X
American Robin	AMRO	R					X	PC	X		
Swainson's Thrush	SWTH	N	X		X	X	X	PC/MN	X	S,F	X
Hermit Thrush	HETH	W[2]				X	X	MN		F,W	X
Orange-crowned Warbler	OCWA	N[3]					X	PC	X		
Yellow Warbler	YEWA	P/N[4]	X	X			X	MN		F	
Wilson's Warbler	WIWA	N	X			X	X	PC/MN	X	S,F	X
Common Yellowthroat	COYE	R	X	X	X		X	PC/MN	X	S,F	
Black-headed Grosbeak	BHGR	N	X				X	PC/MN	X	S	
Spotted Towhee	SPTO	R				X	X	PC	X		
Golden-crowned Sparrow	GCSP	W				X	X	MN		F,W	X
Fox Sparrow	FOSP	W	X		X		X	MN		F,W	X
Lincoln's Sparrow	LISP	W/P			X		X	MN		F	
Song Sparrow	SOSP	R	X			X	X	PC/MN	X	S,F,W	X
Purple Finch	PUFI	R					X	PC/MN	X	S	

[1] **N**=Neotropical migrant that breeds in PORE/GOGA (and other individuals may pass through on migration); **R**=year-round resident (population may also include some migrant individuals); **P**=passage migrant (predominantly in PORE/GOGA in spring and/or fall); **W**=winters in PORE/GOGA (and other individuals may pass through on migration).

[2] Predominantly wintering populations at our study sites, but other populations breed in the region; [3] Predominantly neotropical or at least long-distance migrant, but some individuals winter in the region; [4] Very localized breeding in PORE/GOGA; most individuals here are passage migrants.

[5] California Partners in Flight focal species for riparian (RHJV 2000), coniferous forest (CalPIF 2002a), oak woodland (CalPIF 2002b) and scrub (CalPIF 2004) habitat types; [6] California Bird Species of Special Concern (Shuford and Gardali 2008); [7] A climate change vulnerability assessment of California's at-risk birds (Gardali et al. 2012);

[8] Allen's Hummingbirds were excluded from PC analysis due to the relatively high number of hummingbirds not identified to species during surveys (especially because Allen's Hummingbirds and the passage-migrant Rufous Hummingbirds, *Selasphorus rufus*, can be difficult to differentiate);

[9] Season included in analysis: **S**=spring/summer (breeding season); **F**=fall; **W**=winter

Surveys began approximately 15 minutes after local sunrise and were completed within four hours, when bird activity is generally the highest. Surveys were not conducted in inclement weather when bird activity or detectability was hampered. Each point was surveyed for a 5-minute sampling period. Biologists with experience identifying birds of the region by sight and sound conducted all point counts.

In 2011, as well as for historic surveys in 2005-2010, point count surveys were conducted twice during the peak landbird breeding season, 1 May to 30 June, with a minimum of 10 days between the two visits and typically once in May and once in June. One exception was ARHO which was only visited once during the May-June period in 2007 (first visit was in April). From 1997-2004, the protocol was typically to conduct three visits from late April to early July, although some transects were only visited twice in certain years (ARHO in 2001, COCA in 1999, CTLA in 2002, LOOL 2002-2004, MRAN in 1997, and PIGU in 2001). Additionally, the Redwood Creek transect (24 points) is divided into two subtransects that are typically visited on different days or by different personnel on the same day.

Mist Netting

Mist netting was also conducted at four of the sites in 2011, and annually at all sites since 2001 (some longer); two are monitored year-round and two during breeding season and fall. Mist netting will continue to be conducted annually at these sites. We generally followed the nationally standardized Monitoring Avian Productivity and Survival protocols (MAPS; DeSante et al. 2000). SOP 7 of the riparian monitoring protocol (Gardali et al. 2010) defines fully how PRBO protocols differ from MAPS protocols; and full details of these protocols are documented in an internal overview of protocols, *The Palomarin Handbook* (available at http://www.prbo.org/cms/docs/palo/HB2012_v14.pdf).

The mist netting stations at Redwood and Lagunitas creeks are operated 1 May through 31 October and have been operated since fall 2001. The mist netting station at Muddy Hollow and Pine Gulch are operated year-round; Muddy Hollow has been in operation since the Mount Vision Fire in 1995, and Pine Gulch since 1994. Nets were run approximately once every 10 days November through mid-August, and once every seven days mid-August through October (to reduce the chance of missing pulses of migrating birds). There are 11 nets at Redwood Creek, and 10 at each of the other sites. PRBO also conducts year-round mist-netting at two mist netting stations at the Palomarin Field Station, but these sites are not in riparian habitat and are not included herein.

All birds captured were identified to species, age, and sex using criteria in Pyle (1997) and most were banded with a uniquely numbered aluminum band provided by the Bird Banding Laboratory of the U.S. Geological Survey/Biological Resources Division. Some species (e.g., gamebirds; hummingbirds at sites other than Palomarin) were not banded due to permitting or logistical constraints. Mist netting was conducted primarily by PRBO interns who received at least two weeks training in safe capture, handling and measuring techniques by their staff supervisor, and by the PRBO staff banding supervisor.

Mist netting was also not conducted during periods of rain, high wind, or other adverse weather conditions, as these can affect not only bird behavior but most importantly bird safety. Net hours (number of hours each net was open) were carefully tracked for standardization.

Analysis

Trends in Abundance from Point Counts

For the purposes of this report, we evaluated two temporal/spatial groups of point count data separately: the five core transects surveyed in all years (1997-2011; "Five Core Transects"); and all 14 transects surveyed in three years (1997, 1998, and 2011; "All Transects"; Table 1). Although each transect was visited 1-3 times per season (typically 2-3; see above), we limited data to all visits conducted between 1 May and 30 June (Appendix B) to control for seasonal differences in encounter probability for some migrant species in late April and differences in detectability due to decreasing vocalizations in early July. We excluded all birds detected over 50 meters away, all flyovers, and all confirmed juvenile bird detections.

For each species, we generated an index of abundance per year by averaging the number of detections per point per visit. We natural log transformed this index and used linear regression to describe the relationship between species abundance and year. For one species, Purple Finch, we added 1 to the annual abundance index before log-transforming to accommodate years with zero detections. We evaluated each trend for statistical significance using $\alpha = 0.05$. While we only test for trends at the scale of the entire study area, we also report abundance indices for individual transects by year. All analyses were conducted in R version 2.13.0 (R Development Core Team 2011); see Supplement A for the R code used. We did not conduct analyses using program DISTANCE because only in recent years was the Variable Circular Plot (VCP) point count protocol used (Table 1), the method required for analyzing detectability by distance from the observer. Any future analyses will always exclude data form the earlier years of these monitoring efforts if DISTANCE is employed.

Trends in Abundance from Mist Netting

We evaluated seasonal trends of mist-net captures from four mist netting stations from the fall of 2001 (when mist netting was first initiated at the two latest-initiated of the four study areas) through the winter of 2011-2012. We separately analyzed trends for fall, winter, and breeding season. We defined seasons for mist net trends as: (1) fall, 18 August through 31 October (2001-2011); (2) winter, 1 December 1 through 29 February (winter 2001-02 through winter 2011-12); (3) breeding season, 1 May through 10 August (2002-2011). We modified the fall and winter capture intervals from the intervals described in the Standard Operating Procedure to more accurately encompass migration and over-wintering periods for the species evaluated, and to more conservatively eliminate passage migrants from winter analyses.

We combined data from the four riparian study sites. For all individuals caught more than once in a season (within a single year), we removed recapture records such that we only consider the number of unique captures in a season. We totaled the number of captures by age (Adult or Hatch-Year) and for all captures (ALL: includes both age classes + unknown-aged birds) within each season. For species for which less than 80% of captures were aged within a season, we only considered total

number of individuals captured and did not evaluate trends by age class. We standardized abundances per 1000 net hours and added 1 before natural log transforming the data. We used linear regression to describe the relationship between this abundance index and year. For age classes which averaged at least five captures a season, we evaluated each trend for statistical significance using $\alpha = 0.05$. All analyses were conducted in R version 2.13.0 (R Development Core Team 2011; see Supplement A for the R code used).

Annual Survival

We estimated annual survival using combined capture histories generated from the four mist-netting sites using data from fall 2001 through winter 2011-2012. For year-round residents and migrant breeders, we used only adult captures; and we included captures of all age classes for over-wintering species. For over-wintering species, we only considered captures from the two sites that are sampled in the winter, Pine Gulch and Muddy Hollow. We removed birds that were ever recorded as seriously injured (although see Spotswood et al. 2012).

In order to limit the data to periods of the year that did not include pulses of passage migrants, we qualitatively examined annual capture phenology of each species and assigned capture windows that were species-specific (Table 3).

Table 3. Mist netting capture windows from riparian landbird monitoring program in PORE and GOGA used for survival analysis.

Capture Season	Species	Capture Window
Migrant Breeders	Pacific-slope Flycatcher	May 1 through July 31
	Warbling Vireo	May 1 through July 31
	Swainson's Thrush	May 1 through July 31
	Wilson's Warbler	May 1 through July 31
	Purple Finch	May 1 through July 31
Year-round Residents	Chestnut-backed Chickadee	May1 through October 31
	Wrentit	May1 through October 31
	Song Sparrow	May1 through October 31
Winter Migrants	Ruby-crowned Kinglet	November 1 through February 29
	Hermit Thrush	November 1 through February 29
	Fox Sparrow	November 1 through March 31
	Golden-crowned Sparrow	October 21 through March 31

We used the package RMark 2.1.0 to write Cormack- Jolly-Seber models for Program MARK 6.1 (Laake et al. 2012; see Supplement A for the R code used). We modeled constant survival and recapture probabilities. We used program RELEASE to evaluate goodness of fit of the global model. We do not report time-varying trends in survival rates at this time due to a lack of sufficient long-term data, but will conduct such analyses in future reports (in 6 or 12 years) once we have a longer-term dataset. At that point the species selected for survival analysis in this report, and for which a single survival metric was produced, may be eligible for survival trend analysis. There may be opportunities in the future to include Palomarin data and/or to include earlier years in order to further

extend the dataset (e.g., banding began at two of the four mist netting stations 6-7 years prior to the 2001 start date used in these analyses); the earliest year included in the analyses herein was 2001, which was the earliest year in which all four riparian mist netting stations were monitored.

Results

For general results from the 2011 field season, see the progress report (Jennings and Humple 2014).

Trends in Abundance

Point Count

We found no evidence of a temporal trend in point count abundance for most focal species across either temporal/spatial analysis approach (Table 4, Figure 2 Appendix C). Negative trends in the five core transects surveyed in all years were identified for Olive-sided Flycatcher ($\beta = -0.082$, $p = 0.034$, Figure 2a) and American Robin ($\beta = -0.057$, $p = 0.031$, Figure 2b). A positive trend was detected for one species, but only when examining all transects in three years only (Orange-crowned Warbler, $\beta = 0.035$, $p = 0.021$; Appendix C and Table 4). There was general agreement between the two approaches ("Five Core Transects" and "All Transects"); for the few species that suggested a positive trend for one approach and negative for the other, the differences were negligible and one or both trends did not approach significance ($p > 0.7$).

Appendix D details the index of abundance for each focal species by year and transect.

Mist Netting

We did not detect trends in mist net captures over time for the majority of species and age classes but instead most appear relatively stable (Tables 5-7 and Figures 3-5). In the breeding season, we detected positive trends for adult ($\beta = 0.049$, $p = 0.01$) and all ($\beta = 0.037$, $p = 0.04$) Wilson's Warblers (Table 5 and Figure 3a), and for adult Purple Finch ($\beta = 0.089$, $p = 0.04$, Table 5 and Figure 3b). In the fall, we detected positive trends for Hatch-Year ($\beta = 0.107$, $p = 0.01$) and all ($\beta = 0.098$, $p = 0.003$) Wilson's Warblers (Table 6 and Figure 4b), and a negative trend for Hatch-Year ($\beta = 0.103$, $p = 0.02$) and all ($\beta = 0.095$, $p = 0.02$) Golden-crowned Sparrows (Table 6 and Figure 4c). In winter, we detected a negative trend for all Ruby-crowned Kinglets ($\beta = 0.093$, $p = 0.03$; Table 7 and Figure 5).

Annual Survival

Annual apparent survival estimates ranged from 0.22 (Ruby-crowned Kinglet) to 0.54 (Fox Sparrow), and for most species were ≥ 0.43 (Table 8). Recapture values range from 0.25 (Fox Sparrow) to 0.65 (Swainson's Thrush). We were unable to estimate apparent survival for Pacific-slope Flycatcher, Warbling Vireo, Chestnut-backed Chickadee or Purple Finch due to small sample sizes. For six of the remaining eight species, goodness of fit testing indicated that the global model adequately fit the data. The global model for the remaining two species, Swainson's Thrush and Wilson's Warbler, only passed Program RELEASE Test 2, but failed to pass Program RELEASE Test 3. Possible explanations for this include the presence of transients in the data or other sources of heterogeneity in capture probability. Thus, estimates for these species are reported tentatively.

Table 4. Trends in focal species abundance from point count data collected during riparian landbird monitoring in PORE, GOGA, and MCOSD, 1997-2011. Results in bold are statistically significant. Also included are California-wide Breeding Bird Survey trends (Sauer et al. 2011).

	Five Core Transects (All Years)		All Transects (1997, 1998, 2011)		BBS CA (1966-2010)	BBS CA (2000-2010)
Species	**Slope (β)**	**p-value**	**Slope (β)**	**p-value**	**Trend (perc/sign)[1]**	**Trend (perc/sign)[1]**
Downy Woodpecker	-0.026	0.482	-0.003	0.854	-0.6 (NS)	0.2 (NS)
Olive-sided Flycatcher	**-0.082**	**0.034**	-0.15	0.175	**-2.8 (-3.4, -2.2)**	**-1.8 (-3.0, -0.2)**
Western Wood-Pewee	-0.048	0.155	-0.025	0.278	**-1.5 (-2.0, -0.9)**	-0.7 (NS)
Pacific-slope Flycatcher	0.031	0.064	0.003	0.809	-0.4 (NS)	0.3 (NS)
Warbling Vireo	0.002	0.89	0.003	0.912	-0.5 (NS)	-0.1 (NS)
Western Scrub-Jay	-0.003	0.914	0.01	0.794	0.3 (NS)	-1.4 (NS)
Chestnut-backed Chickadee	0.002	0.842	0.025	0.11	**-1.7 (-2.8, -0.5)**	-1.9 (NS)
Bewick's Wren	-0.01	0.739	0.04	0.07	-0.5 (NS)	-0.1 (NS)
Wrentit	0.008	0.701	0.003	0.944	**-0.8 (-1.3, -0.2)**	-0.9 (NS)
American Robin	**-0.057**	**0.031**	-0.007	0.438	**-0.4 (-0.7, -0.0)**	0 (NS)
Swainson's Thrush	-0.002	0.883	0	0.989	-0.1 (NS)	0.9 (NS)
Orange-crowned Warbler	0.016	0.302	**0.035**	**0.021**	-0.5 (NS)	0.9 (NS)
Common Yellowthroat	0.005	0.827	-0.025	0.329	**1.8 (0.2, 3.3)**	0 (NS)
Wilson's Warbler	-0.004	0.738	0	0.994	**-1.6 (-2.4, -0.7)**	-0.5 (NS)
Black-headed Grosbeak	-0.024	0.153	-0.007	0.861	0.2 (NS)	0.7 (NS)
Spotted Towhee	0.038	0.161	0.06	0.273	0.3 (NS)	-0.2 (NS)
Song Sparrow	-0.023	0.09	-0.016	0.235	**0.6 (0.1, 1.1)**	0.7 (NS)
Purple Finch	0	0.894	-0.001	0.803	**-1.5 (-2.1, -0.9)**	-0.9 (NS)

[1]BBS trend (Sauer et al. 2011) is the yearly percentage change, calculated as the ratio of endpoints from the annual indices produced in the hierarchical model analysis. If the 2.5 and 97.5 percentiles include zero, "NS" follows the trend statistic (=Not Significant); if the 2.5 and 97.5 percentiles does not include zero, the result (according to BBS) may be significant; for these, the percentiles follow the trend statistic, and the result is bolded.

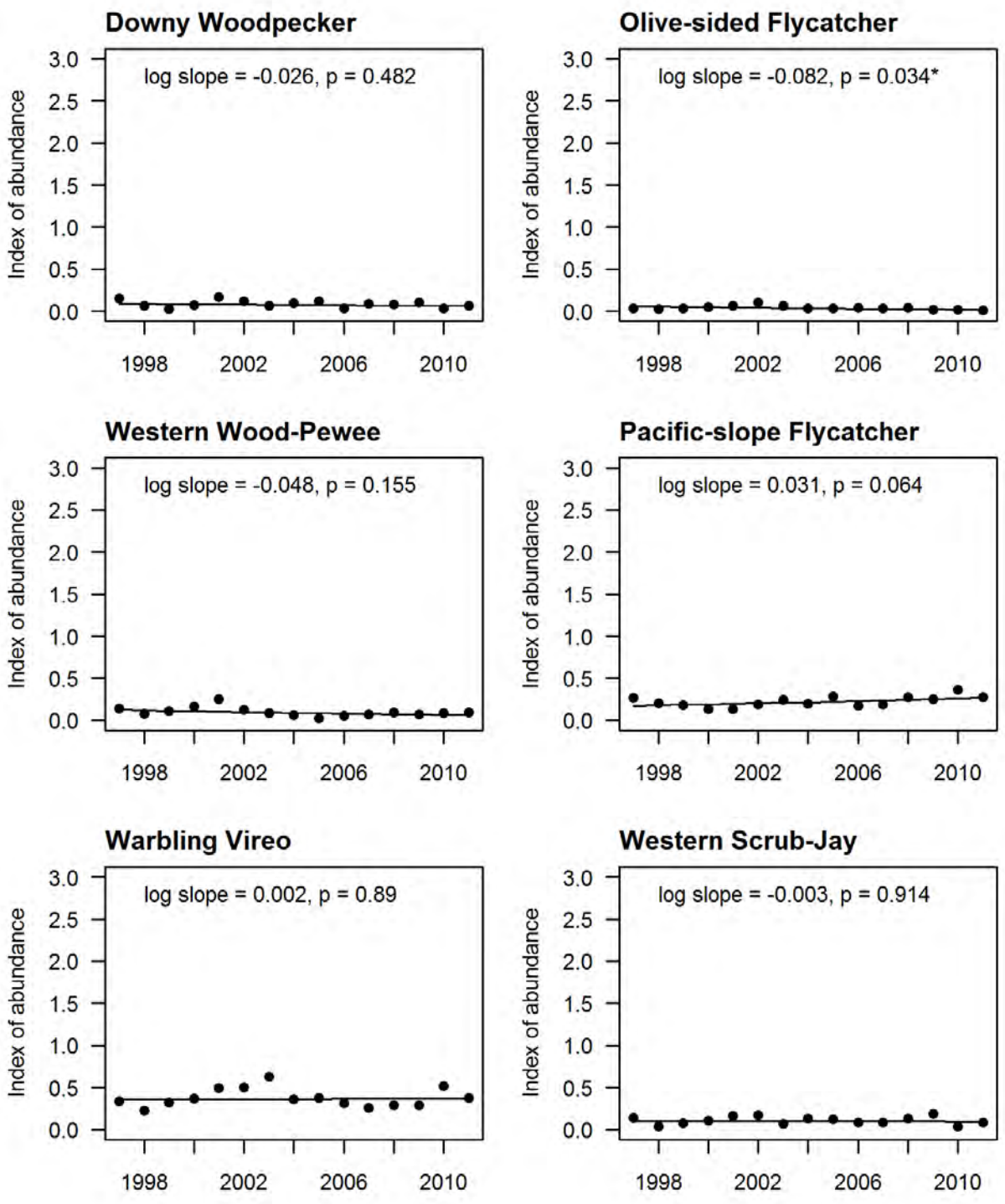


Figure 2a. Trends in focal species abundance from point count data collected during riparian landbird monitoring in PORE, GOGA, and MCOSD for all years (1997-2011) across the five core transects. Significant results are indicated with an asterisk.

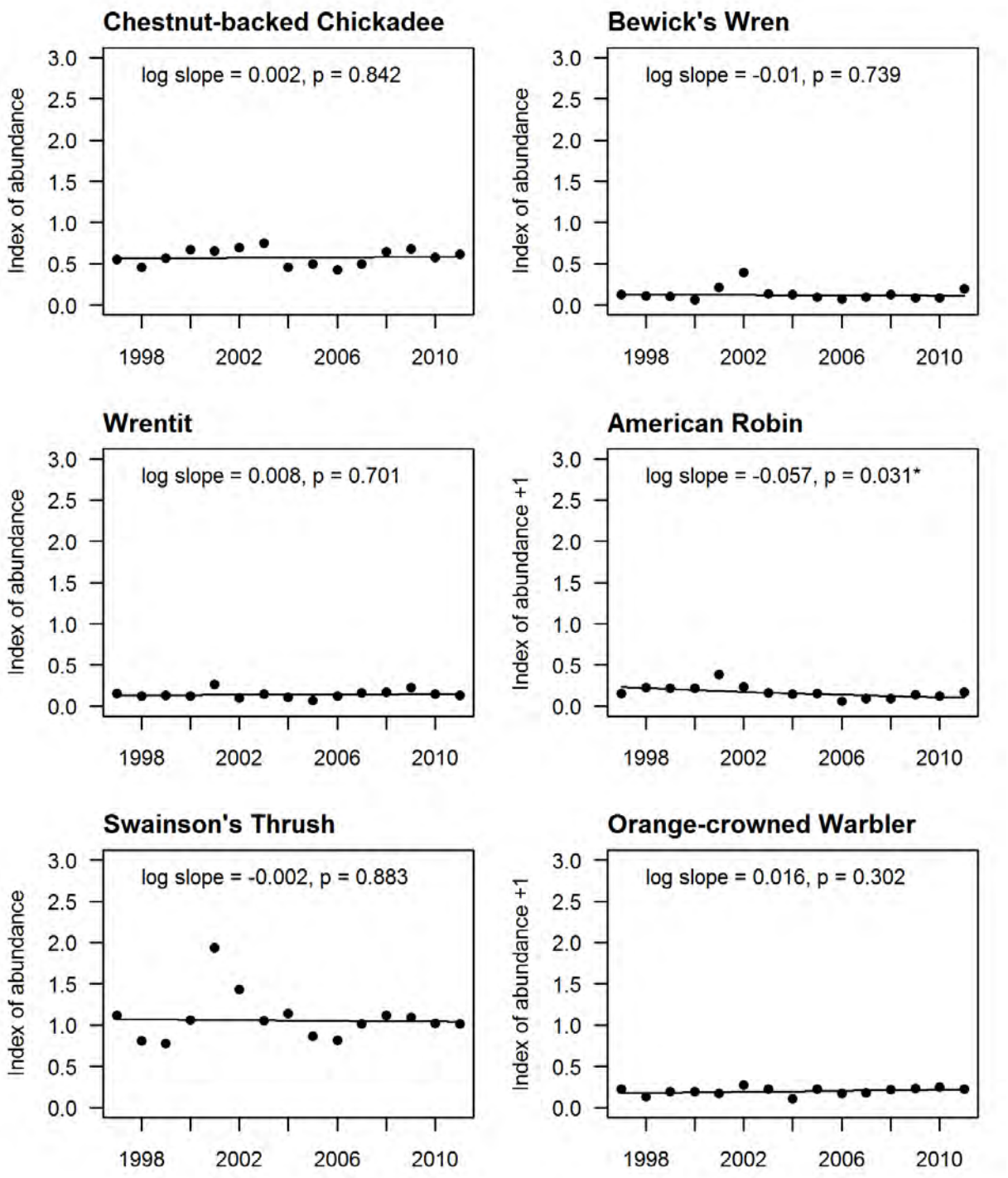


Figure 2b. Trends in focal species abundance from point count data collected during riparian landbird monitoring in PORE, GOGA, and MCOSD for all years (1997-2011) across the five core transects. Significant results are indicated with an asterisk.

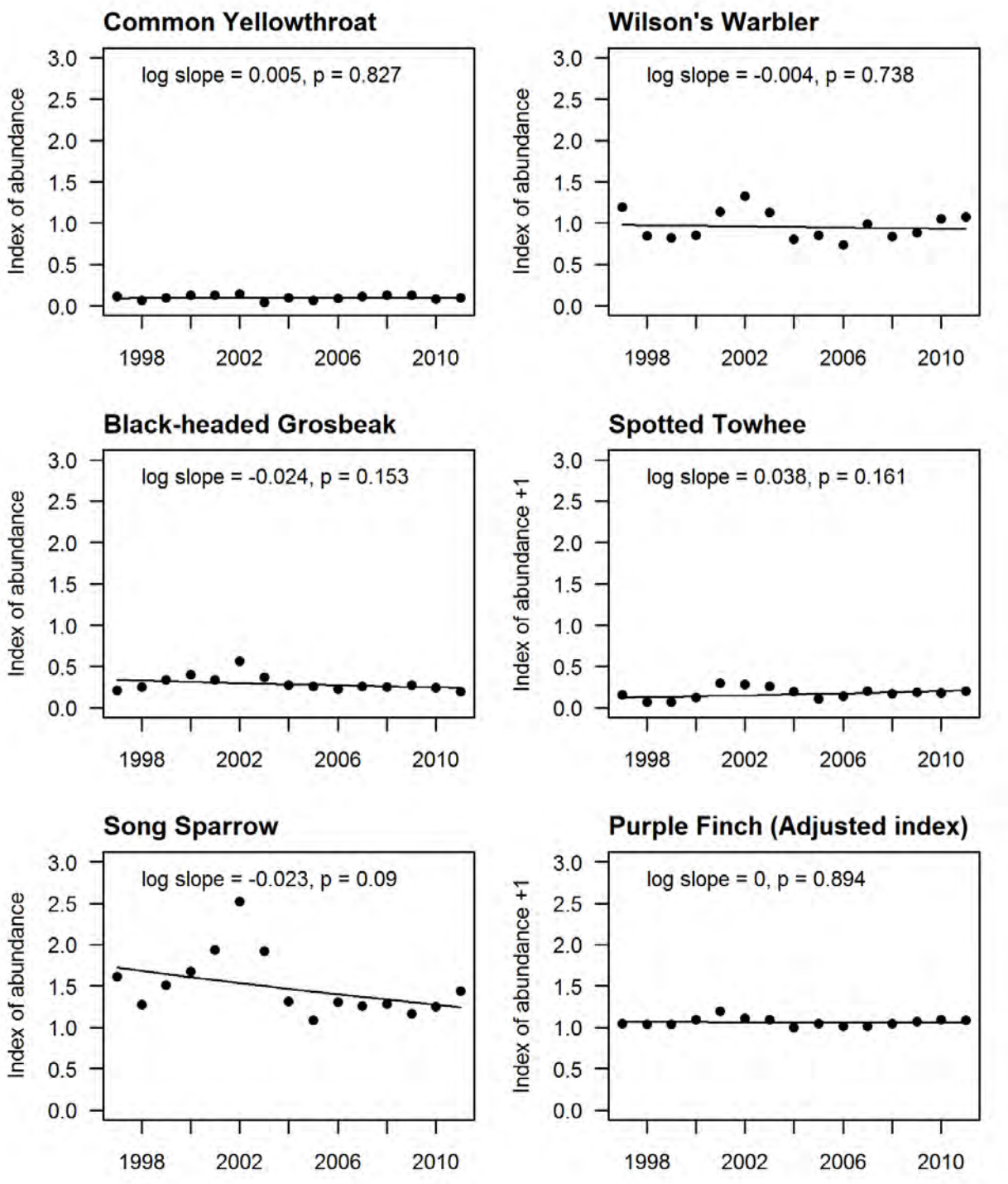


Figure 2c. Trends in focal species abundance from point count data collected during riparian landbird monitoring in PORE, GOGA, and MCOSD for all years (1997-2011) across the five core transects. Significant results are indicated with an asterisk.

Table 5. Trends in capture rate during the breeding season (1 May – 10 Aug) of focal riparian landbird species from banding data from riparian mist netting stations in PORE, GOGA, and MCOSD for 2002-2011. AHY = Adult (After Hatching-Year) birds; HY = Hatching-Year birds (immatures); and ALL = all age classes combined, including AHY + HY + unknown-aged birds. Results in bold are statistically significant.

Species	Age class	Mean	# Years with 0 captures	Linear trend (β)	S.E.	Adj R^2	P-value
ALHU	AHY	22.5	0	-0.021	0.04	-0.09	0.65
	HY	69.8	0	-0.069	0.04	0.20	0.11
	ALL	93.1	0	-0.060	0.04	0.13	0.17
PSFL	AHY	5.2	0	0.018	0.04	-0.09	0.63
	HY	12.3	0	0.025	0.02	0.03	0.29
	ALL	17.7	0	0.026	0.02	0.03	0.29
WAVI	AHY	5.0	0	-0.008	0.05	-0.12	0.88
	HY	8.2	0	-0.053	0.04	0.04	0.27
	ALL	13.6	0	-0.038	0.04	0.00	0.34
CBCH	AHY	10.9	0	-0.006	0.05	-0.12	0.90
	HY	26.2	0	0.036	0.03	0.04	0.28
	ALL	37.9	0	0.022	0.03	-0.07	0.55
WREN	AHY	12.5	0	0.074	0.04	0.20	0.11
	HY	24.0	0	0.016	0.02	-0.06	0.51
	ALL	37.2	0	0.043	0.03	0.15	0.15
SWTH	AHY	119.1	0	0.006	0.03	-0.12	0.81
	HY	41.0	0	0.010	0.04	-0.12	0.80
	ALL	161.6	0	0.007	0.02	-0.10	0.67
COYE	AHY	8.6	0	-0.003	0.03	-0.12	0.92
	HY	10.7	0	0.010	0.04	-0.11	0.79
	ALL	19.6	0	0.005	0.02	-0.12	0.82
WIWA	**AHY**	**72.1**	**0**	**0.049**	**0.02**	**0.50**	**0.01**
	HY	97.7	0	0.026	0.03	-0.01	0.36
	ALL	**173.1**	**0**	**0.037**	**0.02**	**0.35**	**0.04**
SOSP	AHY	75.5	0	-0.012	0.02	-0.06	0.50
	HY	128.8	0	-0.004	0.02	-0.12	0.87
	ALL	208.7	0	-0.005	0.01	-0.11	0.75
BHGR	AHY	8.3	0	-0.050	0.05	-0.02	0.38
	HY	1.1	3	N/A	N/A	N/A	N/A
	ALL	9.5	0	-0.058	0.05	0.03	0.29
PUFI	**AHY**	**15.7**	**0**	**0.089**	**0.04**	**0.35**	**0.04**
	HY	6.4	0	-0.021	0.05	-0.10	0.66
	ALL	22.3	0	0.053	0.04	0.11	0.19

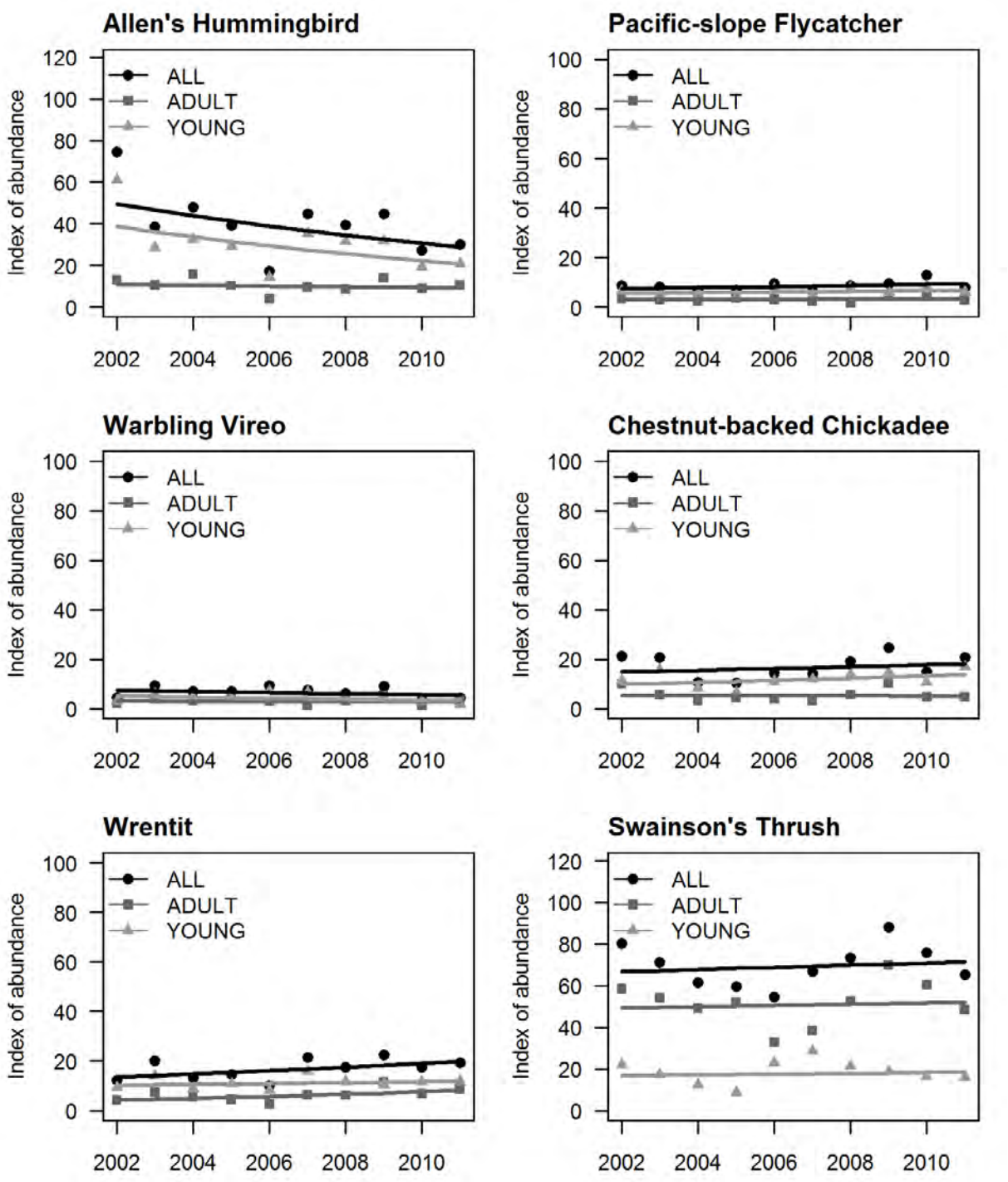


Figure 3a. Trends in capture rate during the breeding season of focal species abundance from banding data from four riparian mist netting stations in PORE, GOGA, and MCOSD, 2002-2011. AHY = Adult (After Hatching-Year) birds, HY = Hatching-Year birds (immatures), and ALL = all age classes combined, including AHY + HY + unknown-aged birds. Significant results are indicated with an asterisk.

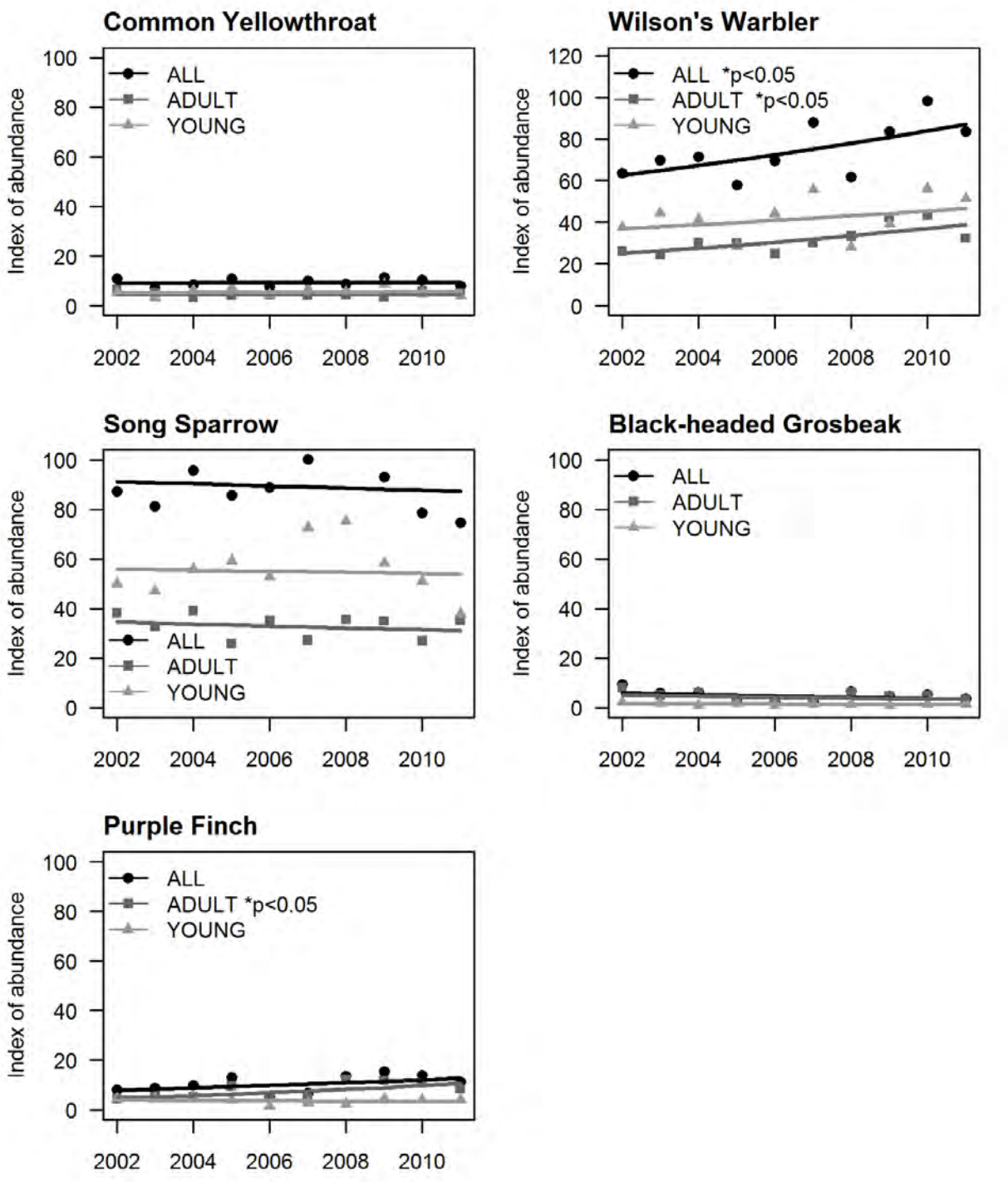


Figure 3b. Trends in capture rate during the breeding season of focal species abundance from banding data from four riparian mist netting stations in PORE, GOGA, and MCOSD, 2002-2011. AHY = Adult (After Hatching-Year) birds, HY = Hatching-Year birds (immatures), and ALL = all age classes combined, including AHY + HY + unknown-aged birds. Significant results are indicated with an asterisk.

Table 6. Trends in capture rate during the fall season (18 Aug – 31 Oct) of focal riparian landbird species from banding data from riparian mist netting stations in PORE, GOGA, and MCOSD for 2001-2011. AHY = Adult (After Hatching-Year) birds, HY = Hatching-Year birds (immatures), and ALL = all age classes combined, including AHY + HY + unknown-aged birds.

Species	Age class	Mean	# Years with 0 captures	Linear trend (β)	S.E.	Adj R^2	P-value
PSFL	AHY	0.4	9	N/A	N/A	N/A	N/A
	HY	30.5	0	-0.028	0.04	-0.04	0.45
	ALL	31.0	0	-0.032	0.04	-0.02	0.39
WAVI	AHY	0.5	7	N/A	N/A	N/A	N/A
	HY	39.1	0	-0.058	0.08	-0.05	0.49
	ALL	41.3	0	-0.057	0.08	-0.06	0.51
CBCH	AHY	2.3	1	N/A	N/A	N/A	N/A
	HY	7.3	0	N/A	N/A	N/A	N/A
	ALL	18.5	0	0.036	0.05	-0.04	0.46
RCKI	AHY	2.6	2	N/A	N/A	N/A	N/A
	HY	6.9	0	N/A	N/A	N/A	N/A
	ALL	29.8	0	-0.085	0.05	0.15	0.13
WREN	AHY	1.5	4	N/A	N/A	N/A	N/A
	HY	14.0	0	N/A	N/A	N/A	N/A
	ALL	19.9	0	0.034	0.03	0.03	0.28
SWTH	AHY	12.7	0	-0.004	0.04	-0.11	0.91
	HY	31.6	0	-0.005	0.03	-0.11	0.89
	ALL	47.5	0	-0.004	0.04	-0.11	0.91
HETH	AHY	10.3	0	-0.021	0.05	-0.09	0.71
	HY	32.3	0	0.000	0.04	-0.11	0.99
	ALL	45.1	0	-0.013	0.03	-0.09	0.66
COYE	AHY	1.9	2	N/A	N/A	N/A	N/A
	HY	13.6	0	0.083	0.05	0.14	0.14
	ALL	16.6	0	0.012	0.04	-0.10	0.76
YEWA	AHY	1.7	3	N/A	N/A	N/A	N/A
	HY	8.6	0	0.000	0.03	-0.11	0.98
	ALL	11.5	0	0.017	0.03	-0.07	0.55
WIWA	AHY	13.3	0	0.067	0.04	0.13	0.15
	HY	**27.2**	**0**	**0.107**	**0.03**	**0.53**	**0.01**
	ALL	**43.8**	**0**	**0.098**	**0.02**	**0.60**	**0.003**
FOSP	AHY	22.9	0	-0.030	0.02	0.13	0.15
	HY	27.6	0	-0.037	0.04	-0.01	0.38
	ALL	54.4	0	-0.031	0.02	0.12	0.16
SOSP	AHY	24.4	0	-0.074	0.04	0.21	0.09
	HY	99.8	0	-0.026	0.02	0.08	0.21
	ALL	152.8	0	-0.029	0.01	0.22	0.08
LISP	AHY	1.9	0	N/A	N/A	N/A	N/A
	HY	16.5	0	-0.006	0.03	-0.11	0.87
	ALL	19.0	0	-0.006	0.03	-0.11	0.88
GCSP	AHY	8.5	0	-0.075	0.03	0.28	0.06
	HY	**16.4**	**0**	**-0.103**	**0.04**	**0.41**	**0.02**
	ALL	**26.3**	**0**	**-0.095**	**0.04**	**0.39**	**0.02**

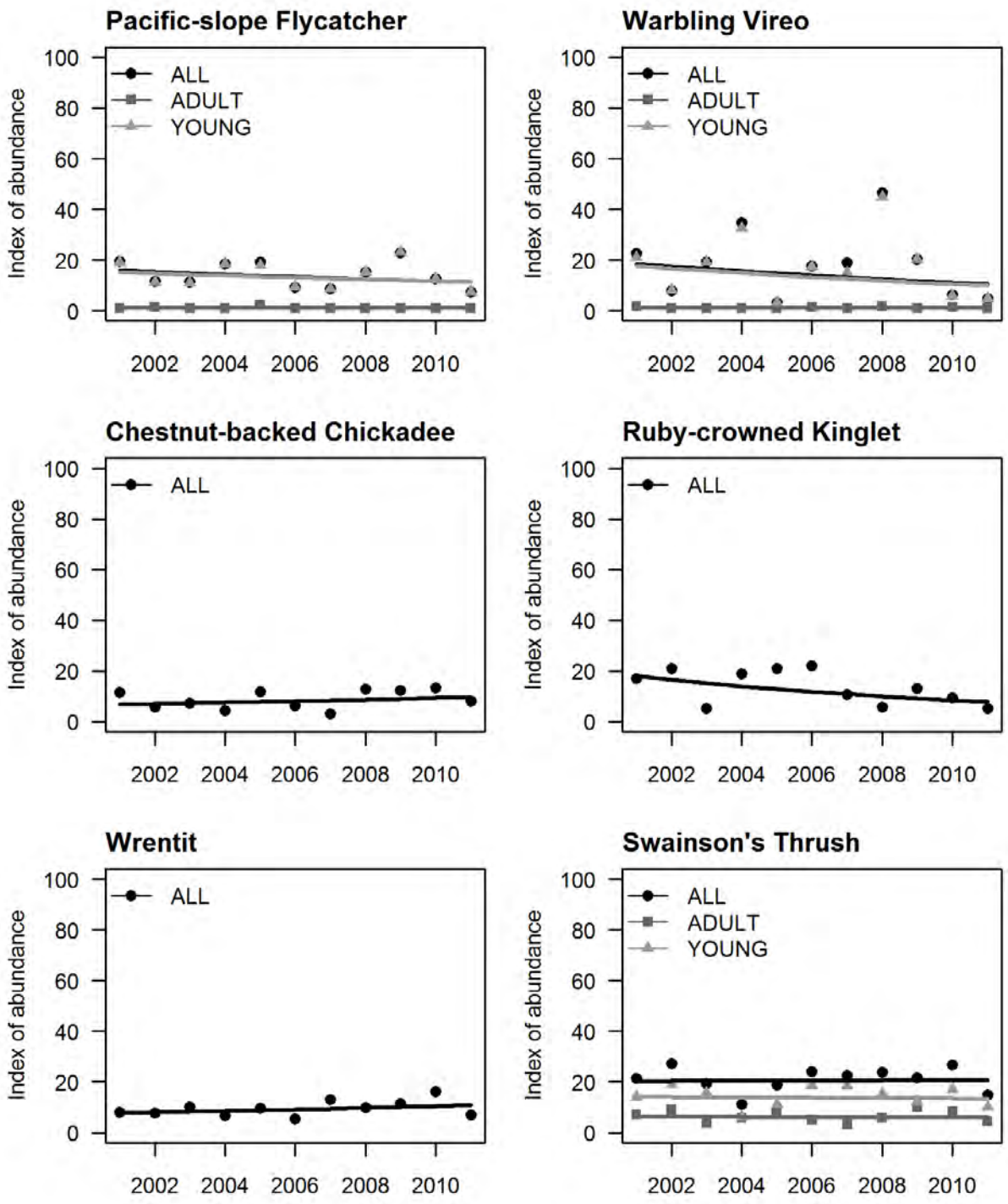


Figure 4a. Trends in capture rate during the fall season of focal species abundance from banding data from four riparian mist netting stations in PORE, GOGA, and MCOSD, 2002-2011. AHY = Adult (After Hatching-Year) birds, HY = Hatching-Year birds (immatures), and ALL = all age classes combined, including AHY + HY + unknown-aged birds. Significant results are indicated with an asterisk.

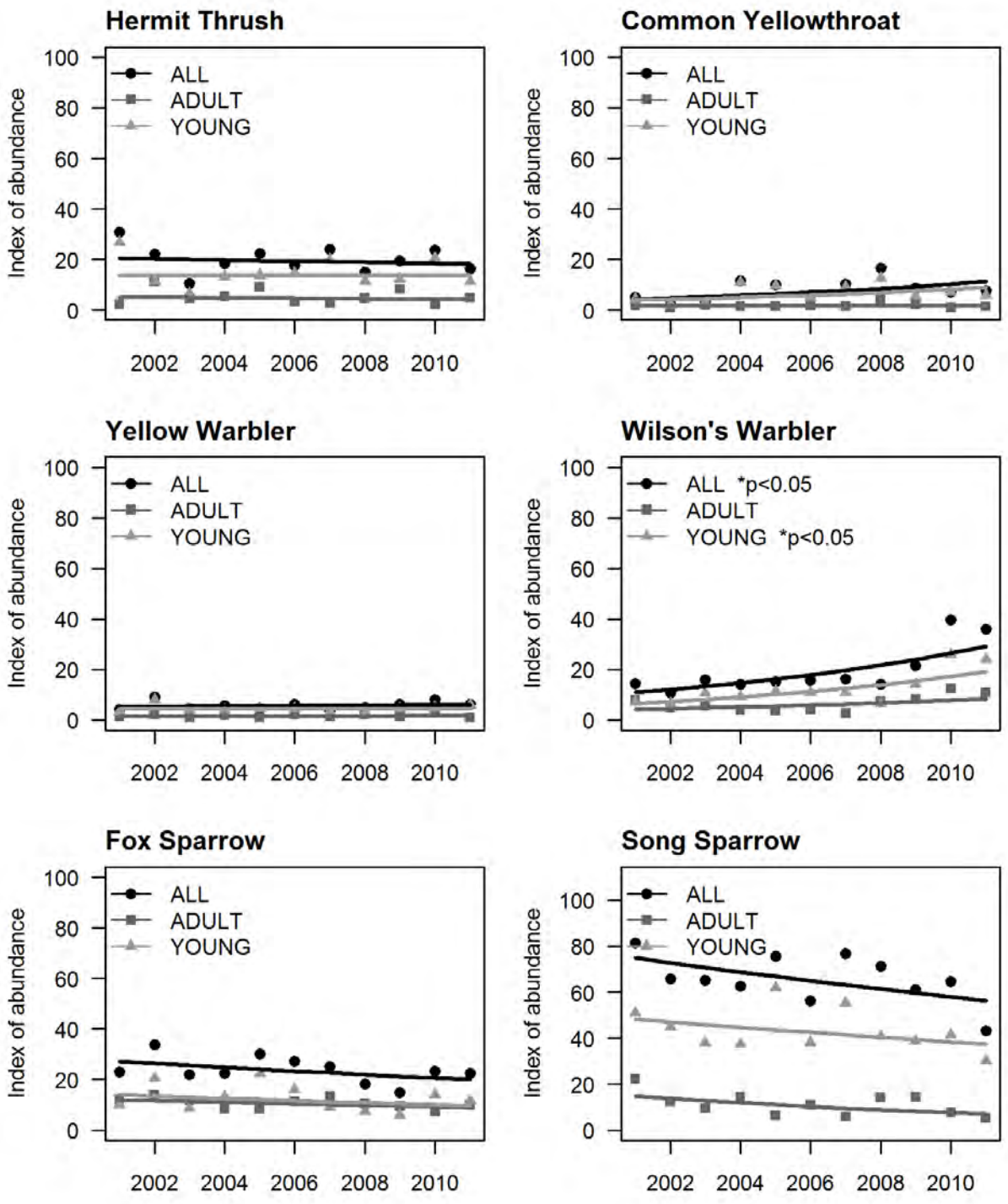


Figure 4b. Trends in capture rate during the fall season of focal species abundance from banding data from four riparian mist netting stations in PORE, GOGA, and MCOSD, 2002-2011. AHY = Adult (After Hatching-Year) birds, HY = Hatching-Year birds (immatures), and ALL = all age classes combined, including AHY + HY + unknown-aged birds. Significant results are indicated with an asterisk.

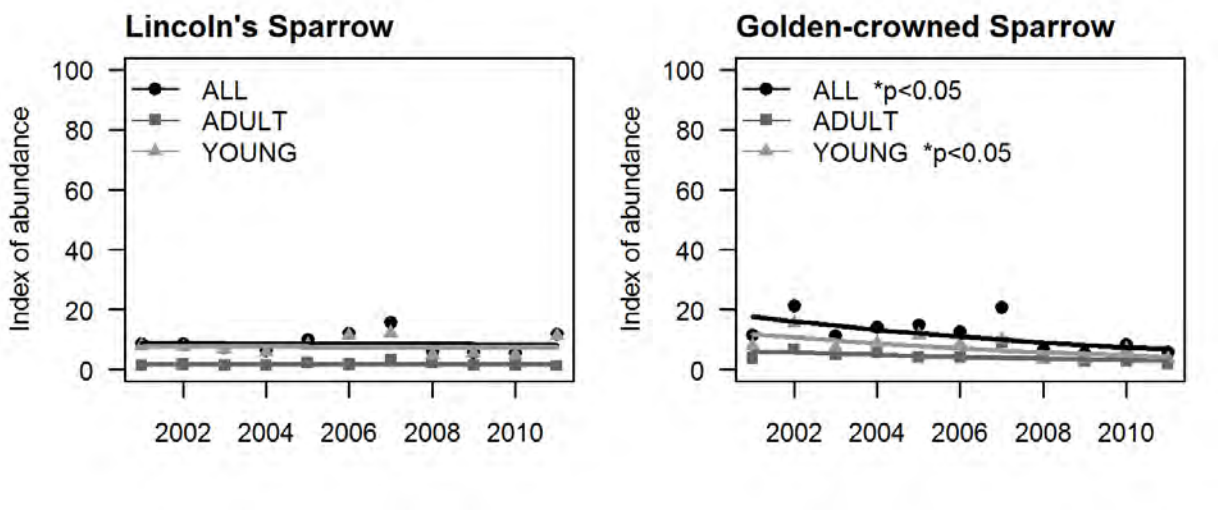


Figure 4c. Trends in capture rate during the fall season of focal species abundance from banding data from four riparian mist netting stations in PORE, GOGA, and MCOSD, 2002-2011. AHY = Adult (After Hatching-Year) birds, HY = Hatching-Year birds (immatures), and ALL = all age classes combined, including AHY + HY + unknown-aged birds. Significant results are indicated with an asterisk.

Table 7. Trends in capture rate during the winter season (1 Dec – 29 Feb) of focal riparian landbird species from banding data from riparian mist netting stations in PORE, GOGA, and MCOSD for 2001-2011. AHY = Adult (After Hatching-Year) birds, HY = Hatching-Year birds (immatures), and ALL = all age classes combined, including AHY + HY + unknown-aged birds. Results in bold are statistically significant.

Species	Age class	mean	# Years with 0 captures	Linear trend (β)	S.E.	Adj R^2	P-value
CBCH	all	8.1	0	-0.003	0.03	-0.11	0.94
RCKI	**all**	**63.2**	**0**	**-0.093**	**0.04**	**0.36**	**0.03**
HETH	all	16.5	0	0.017	0.03	-0.07	0.59
FOSP	all	25.1	0	0.057	0.04	0.10	0.19
SOSP	all	45.8	0	0.007	0.03	-0.10	0.81
GCSP	all	10.5	0	0.097	0.05	0.20	0.10

Table 8. Apparent survival of focal species from banding data from four riparian mist netting stations in PORE, GOGA, and MCOSD, 2001-2011.

Species	Survival Probability (SE, 95% CI)	Recapture Probability (SE, 95% CI)
Ruby-crowned Kinglet	0.22 (0.03, 0.17-0.27)	0.58 (0.08, 0.42-0.72)
Wrentit	0.51 (0.07, 0.38-0.63)	0.45 (0.10, 0.28-0.64)
Swainson's Thrush*	0.45(0.02; 0.42-0.49)	0.65 (0.03, 0.58-0.71)
Hermit Thrush	0.47 (0.05, 0.37-0.57)	0.33 (0.07, 0.22-0.47)
Wilson's Warbler*	0.43 (0.04, 0.36-0.50)	0.36 (0.05, 0.28-0.46)
Fox Sparrow	0.54 (0.04, 0.45-0.62)	0.25 (0.04, 0.18-0.35)
Song Sparrow	0.51 (0.02, 0.47-0.56)	0.48 (0.04, 0.41-0.55)
Golden-crowned Sparrow	0.45 (0.05, 0.34-0.55)	0.31 (0.07, 0.20-0.46)

*Global model passed Program RELEASE Test 2; failed to pass Program RELEASE Test 3.

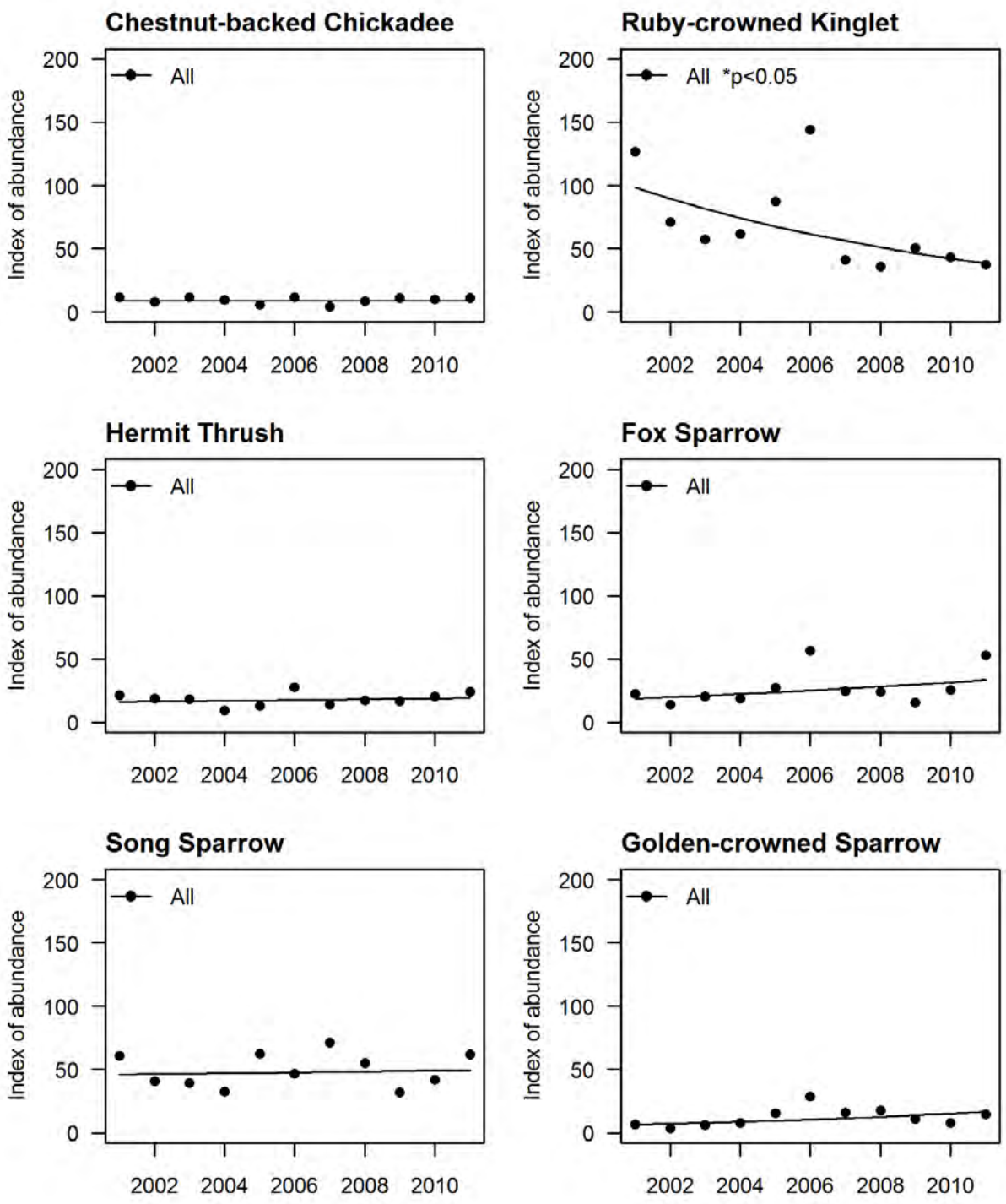


Figure 5. Trends in capture rate during the winter season of focal species abundance from banding data from four riparian mist netting stations in PORE, GOGA, and MCOSD, 2002-2011. ALL = all age classes combined, including AHY + HY + unknown-aged birds. Significant results are indicated with an asterisk.

Discussion

Selection of Focal Species

This report is our first attempt to generate a list of focal species for the riparian landbird monitoring program in PORE and GOGA, and to analyze trends in those focal species. Based on multiple criteria, including conservation concern and habitat association, we generated a list of 25 focal species.

The most common landbirds detected in riparian habitat in the parks included Song Sparrow, Swainson's Thrush, Wilson's Warbler, Allen's Hummingbird, Fox Sparrow and Ruby-crowned Kinglet. The remaining 19 focal species varied in abundance, and we excluded other potential focal species for which we had few detections or captures. Some of the focal species are migratory and only present in certain seasons. Some that breed here could only be analyzed with one of the two methods (e.g., with point count data if their capture rates from mist netting were relatively low). For those adequately sampled by mist netting, trends could only be assessed by age class for some species due either to low sample sizes of an age class or poor ability to age certain species in a given season.

These 25 species will likely remain the focus of the next analysis and synthesis report. Additional years of data may allow us to make stronger inferences for the focal species with relatively low sample sizes.

Overall Patterns

Our results indicate that landbird abundance has been generally stable throughout riparian areas in PORE and GOGA over the last 11 to 15 years. Although there were some increases and some decreases, neither trend dominated the patterns observed.

One benefit of a multi-species approach to monitoring is that we can look for commonalities in life history strategies among the populations showing significant trends, which might provide evidence of a mechanism for increases or declines. For example, if trends of the same direction were seen across several species with similar habitat requirements, it might suggest that changes in habitat quality or availability are affecting population health of these species. In our case, we see little commonality across the species that show trends; the species with significant or apparent trends have a range of habitat and food preferences, and their migratory status includes resident, winter resident, and Neotropical migrants.

Species-Specific Trends

Although most of the 25 focal species appeared stable, a few trends were observed, including both increases and declines for individual species. When looking at both significant and non-significant patterns, there is no indication that overall the riparian bird population is responding consistently.

Significant increases were found in two species. Wilson's Warblers showed an increase in mist-net captures in the summer and fall. No trend was observed in point count data set for this species, where they appeared stable. Purple Finches showed an increase in mist-net captures in summer; once again,

the point count dataset indicated the population to be relatively stable. The stable-to-increasing pattern in both these species is especially encouraging given that the Breeding Bird Survey (BBS) data show both to be decreasing statewide (Sauer et al. 2011). The significant Orange-crowned Warbler increase shown only in the three-year dataset (1997, 1998, and 2011) does not appear to be biologically meaningful.

Significant declines were observed in four species. A decline was observed for breeding Olive-sided Flycatchers, a California Bird Species of Special Concern (Shuford and Gardali 2008, Widdowson 2008) for which declines have also been observed from BBS data (Sauer et al. 2011). Although habitat loss and degradation are considered the primary threats to this species (Widdowson 2008), and likely not a threat in PORE/GOGA, such habitat alteration on their wintering grounds in the tropics (Marshall 1988) may be driving population trends here and throughout the state. Olive-sided Flycatchers have the lowest productivity rate of all North American songbirds (Widdowson 2008) and therefore factors influencing their survival are particularly relevant; unfortunately, we rarely catch this species in mist nets and thus cannot examine survival. Interestingly, this species was recently found to be increasing in the nearby Marin Municipal Water District (Cormier et al. 2011).

Ruby-crowned Kinglets, a winter resident, also showed a significant decline during winter. And although their trend in fall was not significant, the apparent decline then may be biologically significant; kinglets were similarly found to be declining in fall at the nearby Palomarin Field Station (Ballard et al. 2003). Although kinglet survival was considerably lower than that of the other species, this is not necessarily contributing to their decline, as a low survival rate is not unexpected in this species given their relatively low longevity compared to other passerines (BBL unpublished data; http://www.pwrc.usgs.gov/BBL/longevity/Longevity_main.cfm).

Golden-crowned Sparrows showed a significant decline in fall, but no evidence of decline (and possibly a slight increase) in winter. They have also been declining at PRBO's Palomarin Field Station (PRBO unpubl. data), and although the mechanism there is at least in part habitat succession, these patterns should be explored further. It is possible that this species is responding to overall landscape-level changes. Researchers at PRBO continue to study the migratory connectivity of Golden-crowned Sparrows (Seavy et al. 2012), which may provide further insight into the local patterns observed.

We also found American Robins to be declining in summer, consistent with BBS statewide declines (Sauer et al. 2011).

A few other species showed nonsignificant trends that might be biologically significant. This included a potential decrease of Allen's Hummingbirds and Western Wood-Pewees (also declining statewide; Sauer et al. 2011) in summer; Warbling Vireos and Fox Sparrows in fall; and Song Sparrows in summer and fall. Increases are apparent (but not significant) in Pacific-slope Flycatchers and Bewick's Wrens in summer; Common Yellowthroats in fall; and Fox Sparrows in winter. Additionally, four species that appeared stable in PORE and GOGA were found to be declining on BBS (Sauer et al. 2011; Chestnut-backed Chickadee and Wrentit) or in the nearby Marin Municipal Water District (Cormier et al. 2011; Western Scrub-Jay and Spotted Towhee).

Comparison among Methods and Seasons

For species with sufficient data or temporal occurrence, we were able to assess trends in more than one sampling method and/or with more than one season. Results were mixed, sometimes consistent between methods (e.g., Song Sparrow) or seasons (e.g., Wilson's Warbler), and sometimes inconsistent between methods (e.g., Wilson's Warbler) or seasons (e.g., Golden-crowned Sparrow). While results were mixed when comparing methods, in no instance was a species' trend opposite from one method to the next; the only difference was when one method showed change and the other stability. The possible conclusions we draw from occasional lack of agreement between methods are that (1) one method might have greater sensitivity to detect changes in abundance; (2) there may be sex-biased population trends occurring (since singing males have a higher probability of detection than females on point counts, if males were stable and females increased you may see a different trend between the methods); or (3) local increases in population size may be driven by local dynamics at one or more sites. It should be noted that for all core study areas except Pine Gulch, the mist netting covers a much smaller portion of a creek than the point count survey does (e.g., 0.5 km vs 3 km), so we may not expect an exact match up between the two methods.

Differences observed between seasons are not necessarily surprising for migratory species. Mist netting in summer and fall (for Neotropical migrants) and in fall and winter (for overwintering species) may not sample completely overlapping populations; fall captures may include individuals originating from different breeding grounds or headed to different wintering grounds than the individuals captured in summer or winter. Understanding trends in migrant species is also complicated by lack of knowledge of whether the mechanism behind the trend is local or occurs in another location in their annual life cycle.

For species in which we were not able to evaluate with both monitoring methods – either because they occurred outside the breeding season or we lack sufficient capture rates – we do not have the same breadth of evidence about the strength of the trend.

Although the results of the two temporal/spatial point count approaches (14 transects in three years vs. 5 transects in all years) are comparable, the former are not given much attention in this report, due to the gap in sampling and the low number of years sampled, especially considering interannual variability. We look forward to making stronger inferences for these locations once we have a longer time series.

Future Considerations

This report summarizes the substantial foundation of riparian landbird monitoring in PORE and GOGA, and identifies the species we are most effectively monitoring with these efforts. By continuing this monitoring and investigation, we will be able to add additional years of data and reassess these trends, increase our power to detect trends in species that to-date appear stable or where apparent trends are not significant, and investigate underlying demographic causes of population change. Additional data will help explain patterns that are not consistent among methods, seasons, or age classes. Going forward, all transects will be surveyed every third year, with core transects continuing to be surveyed annually.

We may be able to expand our investigation by comparing populations in riparian areas of PORE and GOGA (as well as MCOSD) to the many decades of data collected at the Palomarin Field Station. Also, for some study sites future analyses could include the point count monitoring that occurred prior to 1997 (e.g., Arroyo Honda, Pine Gulch) or the mist netting that occurred prior to 2001 (e.g., Muddy Hollow, Pine Gulch), not included herein. We may want to explore some site-specific patterns, especially if they may be driving the overall pattern (e.g., looking at the detailed point count data for each site, are declines in American Robin driven by changes at Redwood Creek and Lagunitas Creek?). Additionally, future years of monitoring will allow us to increase our survival analysis and eventually assess trends in survival, and to potentially include detectability in our point count analyses using Program DISTANCE for later years in the time series for which the Variable Circular Plot survey method was employed.

This comprehensive long-term monitoring program will help us maintain a detailed understanding of landbird population health within the Point Reyes National Seashore and Golden Gate Recreation Area.

Literature Cited

American Ornithologists' Union (AOU). 1983. Check-list of North American Birds. 7th edition. American Ornithologists' Union, Washington, D.C.

American Ornithologists' Union (AOU). 2012. Fifty-third supplement to the American Ornithologists' Union check-list of North American birds. Auk 129: 573−588.

Ballard, G., G. R. Geupel, N. Nur, and T. Gardali. 2003. Long-term declines and decadal patterns in population trends of songbirds in western North America, 1979-1999. The Condor 105:737-755.

California Partners in Flight (CalPIF). 2002a. Version 1.1. The coniferous forest bird conservation plan: a strategy for protecting and managing coniferous forest habitats and associated birds in California (J. Robinson and J. Alexander, lead authors). PRBO Conservation Science, Petaluma, CA. Available online: http://www.prbo.org/calpif/plans.html.

California Partners in Flight (CalPIF). 2002b. Version 2.0. The oak woodland bird conservation plan: a strategy for protecting and managing oak woodland habitats and associated birds in California (S. Zack, lead author). Point Reyes Bird Observatory, Stinson Beach, CA. Available online: http://www.prbo.org/calpif/plans.html.

California Partners in Flight (CalPIF). 2004. Version 2.0. The coastal scrub and chaparral bird conservation plan: a strategy for protecting and managing coastal scrub and chaparral habitats and associated birds in California (J. Lovio, lead author). PRBO Conservation Science, Stinson Beach, CA. Available online: http://www.prbo.org/calpif/plans.html.

Carignan, V., and M-A. Villard. 2002. Selecting indicator species to monitor ecological integrity: A review. Environmental Monitoring and Assessment 78:45-61.

Cormier, R. L., N. E. Seavy, S. Jennings, and T. Gardali. 2011. Abundance patterns in landbirds in the Marin Municipal Water District over 15 years: 1996 to 2010. A report to the Marin Municipal Water District.

DeSante, D. F., K. M. Burton, P. Velez, and D. Froehlich. 2000. MAPS Manual: 2000 protocol. The Institute for Bird Populations, Point Reyes Station, CA.

Gardali, T., D. Humple, M. Herzog, M. Koenen, D. Press, W. Merkle, and S. Allen. 2010. Riparian landbird monitoring protocol for Golden Gate National Recreation Area and Point Reyes National Seashore: version 4.4. Natural Resource Report NPS/SFAN/NRR-2010/207. National Park Service, Fort Collins, CO.

Gardali, T, N. E. Seavy, R. T. DiGaudio, and L. A. Comrack. 2012. A climate change vulnerability assessment of California's at-risk birds. PLoS ONE 7(3):e29507.doi:10.1371/journal.pone.0029507.

Hutto, R. L. 1998. Using landbirds as an indicator species group. Pages 75–92 *in*: J. M. Marzluff, and R. Sallabanks (editors). Avian conservation: Research and management. Island Press, Covelo, CA.

Jennings, S., and D. L. Humple. 2014. Riparian landbird monitoring in Golden Gate National Recreation Area and Point Reyes National Seashore: Progress report for 2011-12. Natural Resource Data Series NPS/SFAN/NRDS—2014/709. National Park Service, Fort Collins, Colorado.

Laake, J., with contributions from E. Rakimberdiev, B. Collier, J. Rotella and A. Paul. 2012. RMark: R code for MARK analysis. R package version 2.1.0. Available online: http://CRAN.R-project.org/package=RMark.

MacMynowski, D. P., T. L. Root, G. Ballard, and G. R. Geupel. 2007. Changes in spring arrival of Nearctic-Neotropical migrants attributed to multiscalar climate. Global Change Biology 13:1-13.

Marshall, J. T. 1988. Birds lost from a giant Sequoia forest during fifty years. Condor 90:359-372.

Porzig, E. L., K. E. Dybala, T. Gardali, G. Ballard, G. R. Geupel, and J. A. Wiens. 2011. Forty-five years and counting: Reflections from the Palomarin Field Station on the contributions of long-term monitoring and recommendations for the future. Condor 113:713-723.

Pyle, P. 1997. Identification guide to North American birds, Part 1. Slate Creek Press, Bolinas, CA.

Ralph, C. J., G. R. Geupel, P. Pyle, T. E. Martin, and D. F. DeSante. 1993. Handbook of field methods for monitoring landbirds. Gen. Tech. Rep. PSW-GTR-144. U.S. Department of Agriculture, U.S. Forest Service, Pacific Southwest Research Station, Albany, CA.

R Development Core Team. 2011. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0. Available online: http://www.R-project.org/.

Riparian Habitat Joint Venture (RHJV). 2000. Version 1.0. The riparian bird conservation plan: a strategy for reversing the decline of riparian associated birds in California. California Partners in Flight. (Conservation Plan Authors: G. Ballard, L. Comrack, G. Elliott, T. Gardali , G. Geupel, D. Humple, M. Lynes, and M. Pitkin). Available online: http://www.prbo.org/CalPIF/Riparian/Riparian.html.

Sauer, J. R., J. E. Hines, J. E. Fallon, K. L. Pardieck, D. J. Ziolkowski, Jr., and W. A. Link. 2011. The North American Breeding Bird Survey, results and analysis 1966 - 2010. Version 12.07.2011. USGS Patuxent Wildlife Research Center, Laurel, MD. Available online: http://www.pwrc.usgs.gov/.

Seavy, N. E., D. L. Humple, R. L. Cormier, and T. Gardali. 2012. Establishing the breeding provenance of a temperate-wintering North American passerine, the Golden-crowned Sparrow, using light-level geolocation. *PLoS ONE* 7(4):e34886.

Shuford, W. D., and T. Gardali (editors). 2008. California bird Species of Special Concern: A ranked assessment of species, subspecies, and distinct populations of immediate conservation concern in California. Studies in Western Birds. Western Field Ornithologists, Camarillo, CA, and California Department of Fish and Game, Sacramento, CA.

Sibley, D. A. 2000. National Audubon Society's The Sibley Guide to Birds, 1st edition. Alfred A. Knopf, Inc., New York and Hong Kong.

Spotswood, E. N., K. R. Goodman, J. Carlisle, R. L. Cormier, D. L. Humple, J. Rousseau, S. L. Guers, and G. G. Barton. 2012. How safe is mist netting? Evaluating the risk of injury and mortality to birds. Methods in Ecology and Evolution 3(1):29-38.

Widdowson, W. P. 2008. Olive-sided Flycatcher (*Contopus cooperi*). Species account *in* W. D. Shuford, and T. Gardali (editors). 2008. California bird Species of Special Concern: A ranked assessment of species, subspecies, and distinct populations of birds of immediate conservation concern in California. Studies of Western Birds 1. Western Field Ornithologists, Camarillo, CA, and California Department of Fish and Game, Sacramento, CA.

Appendix A. Scientific names of focal species selected for analysis following nomenclature* from AOU 2012 (AOU 1983, 2012).

Common Name	Scientific Name
Downy Woodpecker	*Picoides pubescens*
Allen's Hummingbird	*Selasphorus sasin*
Olive-sided Flycatcher	*Contopus cooperi*
Western Wood-Pewee	*Contopus sordidulus*
Pacific-Slope Flycatcher	*Empidonax difficilis*
Warbling Vireo	*Vireo gilvus*
Western Scrub-Jay	*Aphelocoma californica*
Chestnut-backed Chickadee	*Poecile rufescens*
Bewick's Wren	*Thryomanes bewickii*
Wrentit	*Chamaea fasciata*
Ruby-crowned Kinglet	*Regulus calendula*
American Robin	*Turdus migratorius*
Swainson's Thrush	*Catharus ustulatus*
Hermit Thrush	*Catharus guttatus*
Orange-crowned Warbler	*Oreothlypis celata*
Yellow Warbler	*Setophaga petechia*
Wilson's Warbler	*Cardellina pusilla*
Common Yellowthroat	*Geothlypis trichas*
Black-headed Grosbeak	*Pheucticus melanocephalus*
Spotted Towhee	*Pipilo maculatus*
Golden-crowned Sparrow	*Zonotrichia atricapilla*
Fox Sparrow	*Passerella iliaca*
Lincoln's Sparrow	*piza lincolnii*
Song Sparrow	*Melospiza melodia*
Purple Finch	*Haemorhous purpureus*

*Taxonomic order follows Sibley 2000 rather than AOU 2012.

Appendix B. Visit dates for riparian point count transects surveyed in PORE, GOGA, and MCOSD for all years and dates that are included in the analyses in this report.

Excluded from this table are visits outside of the seasonally-selected analysis window [May-June], and interim years (during the 1999-2010 period) for non-core study sites that were not included in the analyses herein; see Table 1 for record of all years surveyed.

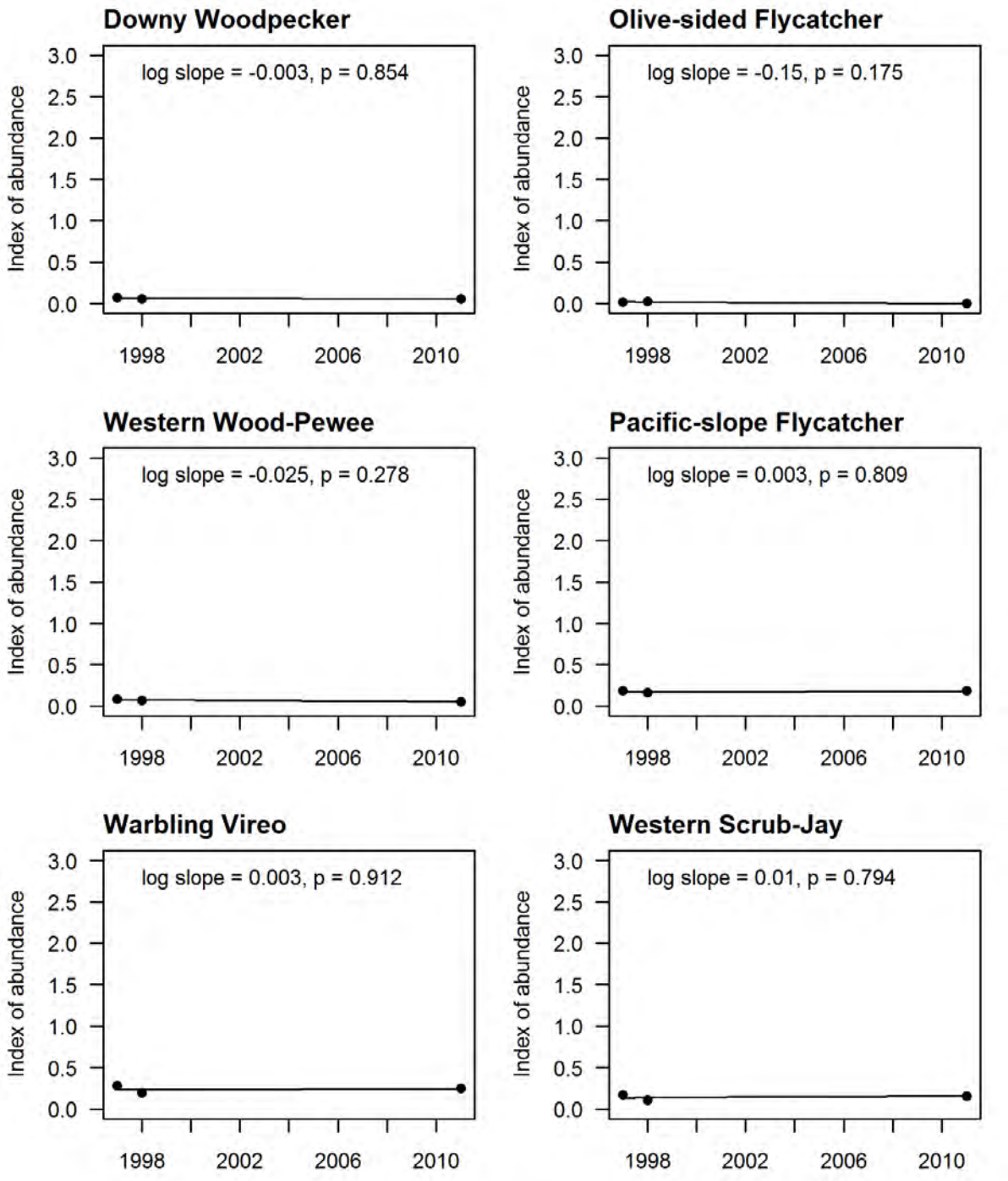
Station	Year	Visit 1	Visit 2	Visit 3
ABKE	1997	5/6/1997	5/30/1997	6/27/1997
	1998	NA	6/3/1998	6/29/1998
	2011	5/24/2011	6/15/2011	NA
ARHO	1997	5/6/1997	5/31/1997	6/26/1997
	1998	5/13/1998	6/9/1998	NA
	1999	NA	6/7/1999	6/30/1999
	2000	5/9/2000	5/23/2000	NA
	2001	5/21/2001	6/11/2001	NA
	2002	5/8/2002	5/31/2002	6/14/2002
	2003	NA	5/31/2003	6/15/2003
	2004	5/2/2004	5/27/2004	6/25/2004
	2005	5/26/2005	6/21/2005	NA
	2006	5/26/2006	6/18/2006	NA
	2007	NA	6/25/2007	NA
	2008	5/11/2008	6/12/2008	NA
	2009	5/13/2009	6/15/2009	NA
	2010	5/14/2010	6/21/2010	NA
	2011	5/11/2011	6/19/2011	NA
BEVA	1997	5/3/1997	5/28/1997	6/24/1997
	1998	NA	6/2/1998	6/25/1998
	2011	5/21/2011	6/23/2011	NA
COCA	1997	5/5/1997	6/10/1997	NA
	1998	5/15/1998	6/3/1998	6/30/1998
	2011	5/20/2011	6/24/2011	NA
CTLA	1997	NA	5/27/1997	6/23/1997
	1998	5/7/1998	5/26/1998	6/29/1998
	2011	5/12/2011	6/10/2011	NA
GERB	1997	5/13/1997	5/21/1997	6/20/1997
	1998	5/5/1998	5/31/1998	6/18/1998
	2011	5/20/2011	6/9/2011	NA
LACR	1997	NA	5/21/1997	6/18/1997
	1998	NA	5/20/1998	6/18/1998
	1999	5/10/1999	5/27/1999	6/16/1999
	2000	5/13/2000	5/25/2000	6/12/2000
	2001	5/23/2001	6/15/2001	6/30/2001

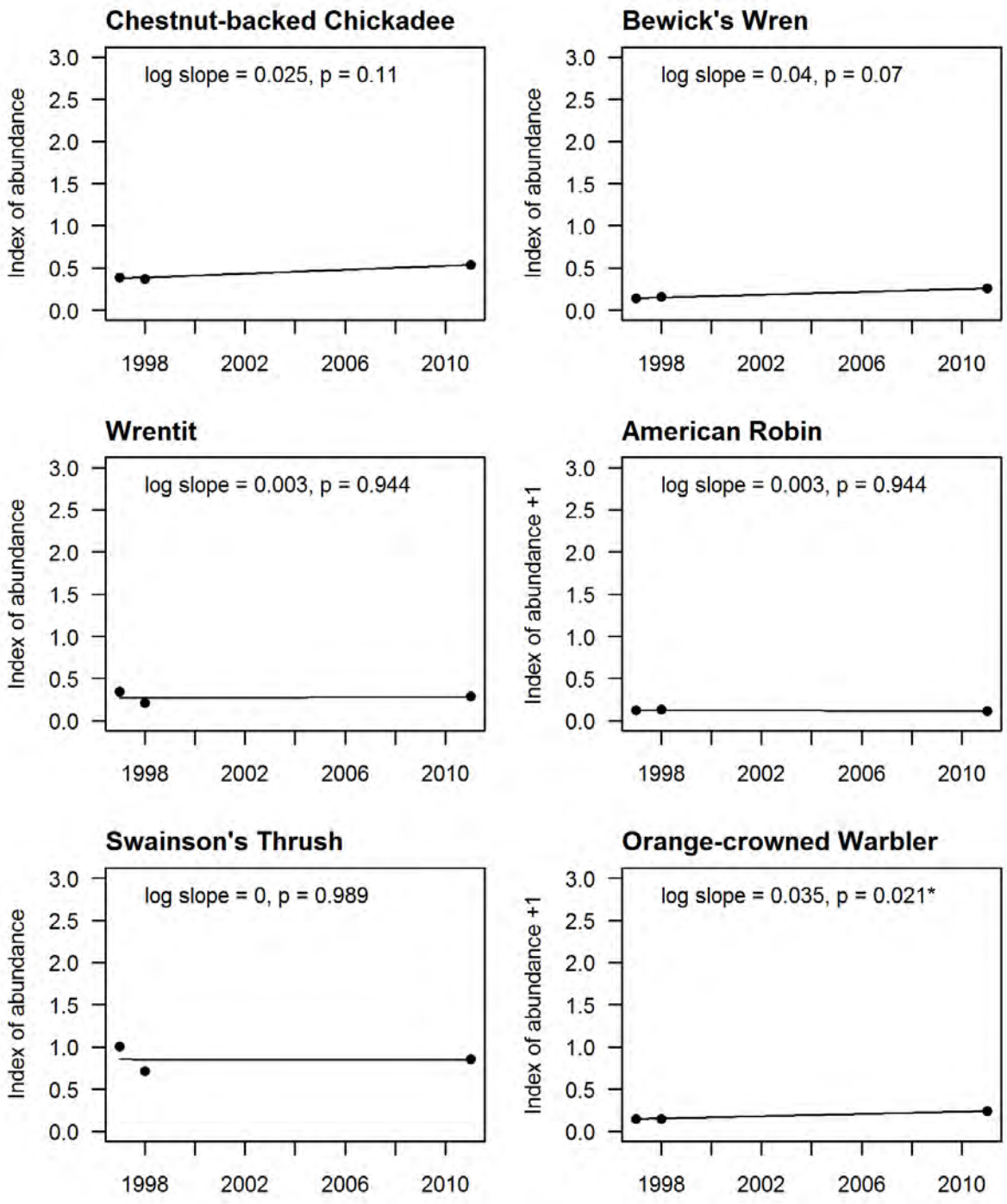
Station	Year	Visit 1	Visit 2	Visit 3
	2002	5/8/2002	5/23/2002	6/11/2002
	2003	5/16/2003	6/4/2003	6/19/2003
	2004	5/4/2004	5/31/2004	NA
	2005	5/19/2005	6/12/2005	NA
	2006	5/24/2006	6/14/2006	NA
	2007	5/8/2007	6/12/2007	NA
	2008	5/20/2008	6/14/2008	NA
	2009	5/29/2009	7/1/2009	NA
	2010	5/28/2010	6/22/2010	NA
	2011	5/26/2011	6/13/2011	NA
LOOL	1997	5/3/1997	6/1/1997	6/27/1997
	1998	NA	6/5/1998	6/26/1998
	2011	5/25/2011	6/10/2011	NA
		5/26/2011		
MRAN	1997	6/25/1997	NA	NA
	1998	5/11/1998	6/11/1998	7/1/1998
	2011	5/20/2011	6/16/2011	NA
MUHO	1997	NA	5/27/1997	6/23/1997
	1998	NA	5/30/1998	6/25/1998
	1999	5/17/1999	6/7/1999	6/22/1999
	2000	5/16/2000	6/6/2000	6/19/2000
			6/19/2000	6/30/2000
	2001	5/27/2001	6/14/2001	6/28/2001
	2002	5/11/2002	5/29/2002	6/9/2002
	2003	5/13/2003	5/31/2003	6/23/2003
	2004	5/9/2004	6/1/2004	6/28/2004
	2005	5/24/2005	6/24/2005	NA
	2006	5/19/2006	6/23/2006	NA
	2007	5/24/2007	6/25/2007	NA
	2008	5/27/2008	6/16/2008	NA
	2009	5/18/2009	6/30/2009	NA
	2010	5/10/2010	6/28/2010	NA
	2011	5/10/2011	6/7/2011	NA
PIGU	1997	5/31/1997	6/12/1997	6/26/1997
	1998	5/13/1998	6/5/1998	6/23/1998
	1999	5/11/1999	6/19/1999	6/30/1999
	2000	5/18/2000	6/29/2000	NA
	2001	5/20/2001	6/28/2001	NA
	2002	5/12/2002	5/30/2002	6/13/2002
	2003	5/4/2003	6/2/2003	6/16/2003
	2004	5/20/2004	6/8/2004	6/30/2004
	2005	5/19/2005	6/14/2005	NA
	2006	5/29/2006	6/12/2006	NA
	2007	6/7/2007	6/18/2007	NA

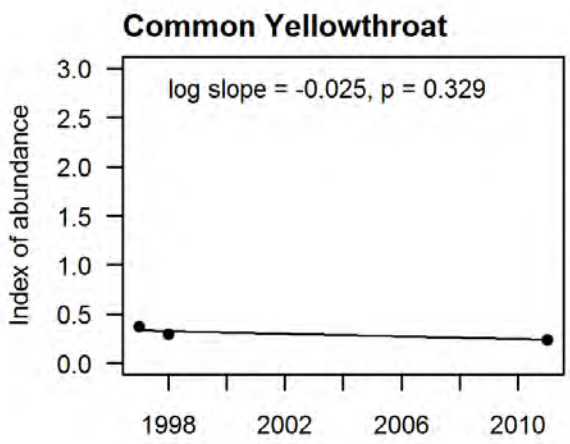
Station	Year	Visit 1	Visit 2	Visit 3
	2008	5/16/2008	6/21/2008	NA
	2009	5/12/2009	6/22/2009	NA
	2010	5/20/2010	6/18/2010	NA
	2011	5/11/2011	6/16/2011	NA
RECR	1997	NA	5/26/1997	6/17/1997
	1998	NA	5/23/1998	6/10/1998
	1999	5/7/1999	5/26/1999	6/12/1999
	2000	5/20/2000	6/2/2000	6/14/2000
		5/23/2000	6/5/2000	6/17/2000
	2001	5/21/2001	6/11/2001	6/26/2001
		5/22/2001	6/12/2001	6/27/2001
	2002	5/9/2002	5/24/2002	6/10/2002
			5/30/2002	6/13/2002
				6/17/2002
	2003	5/15/2003	5/30/2003	6/17/2003
		5/20/2003		
	2004	5/1/2004	5/18/2004	6/25/2004
			5/19/2004	
	2005	5/27/2005	6/16/2005	NA
		5/31/2005	6/22/2005	
	2006	5/15/2006	6/20/2006	NA
		5/24/2006	6/21/2006	
	2007	5/29/2007	6/17/2007	NA
		5/31/2007	6/21/2007	
	2008	5/20/2008	6/14/2008	NA
		5/30/2008	6/20/2008	
	2009	5/13/2009	6/19/2009	NA
			6/26/2009	
	2010	5/5/2010	6/24/2010	NA
		5/7/2010	6/29/2010	NA
	2011	5/9/2011	6/2/2011	NA
		5/16/2011	6/22/2011	
TEVA	1997	NA	5/20/1997	6/17/1997
	1998	NA	5/30/1998	6/17/1998
	2011	5/20/2011	6/27/2011	NA
UPOL	1997	NA	5/28/1997	6/24/1997
	1998	NA	6/1/1998	6/24/1998
	2011	5/27/2011	6/14/2011	NA

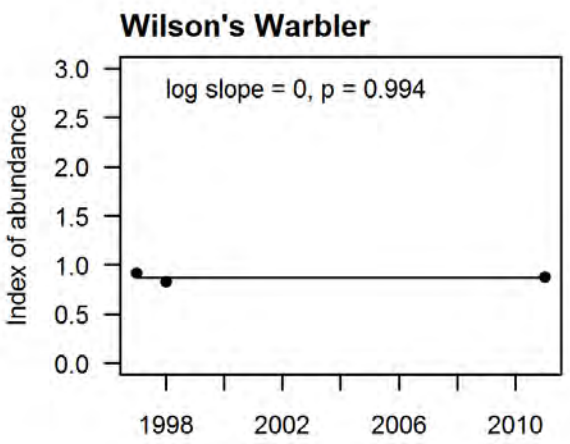
Appendix C. Trends in focal species abundance from point count data collected during riparian landbird monitoring in PORE, GOGA, and MCOSD for three years (1997, 1998, and 2011) across all 14 transects.

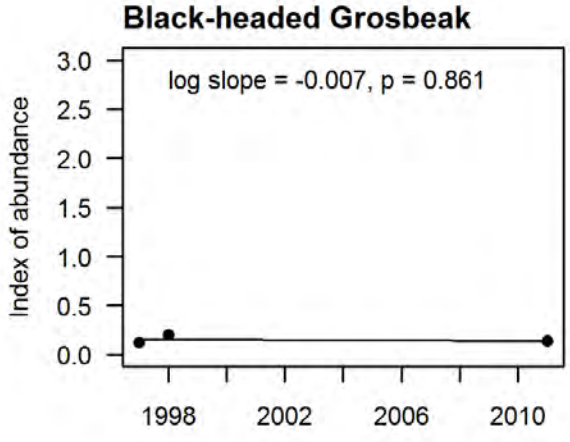
Significant results are indicated with an asterisk.

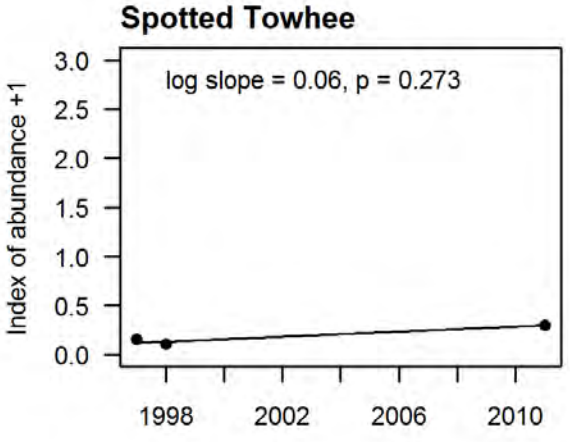


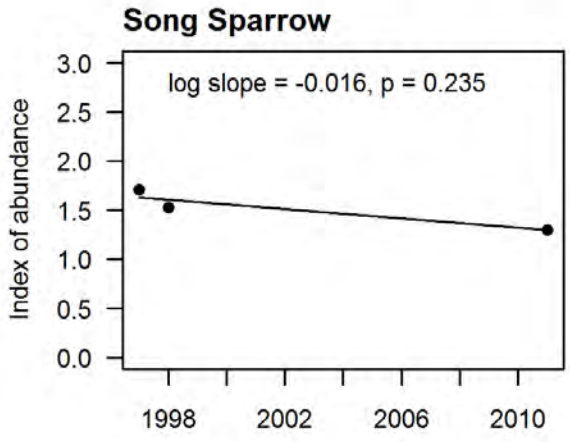

Chestnut-backed Chickadee
log slope = 0.025, p = 0.11
Index of abundance
Bewick's Wren
log slope = 0.04, p = 0.07
Index of abundance
Wrentit
log slope = 0.003, p = 0.944
Index of abundance
American Robin
log slope = 0.003, p = 0.944
Index of abundance +1
Swainson's Thrush
log slope = 0, p = 0.989
Index of abundance
Orange-crowned Warbler
log slope = 0.035, p = 0.021*
Index of abundance +1
0.0
0.5
1.0
1.5
2.0
2.5
3.0
1998
2002
2006
2010

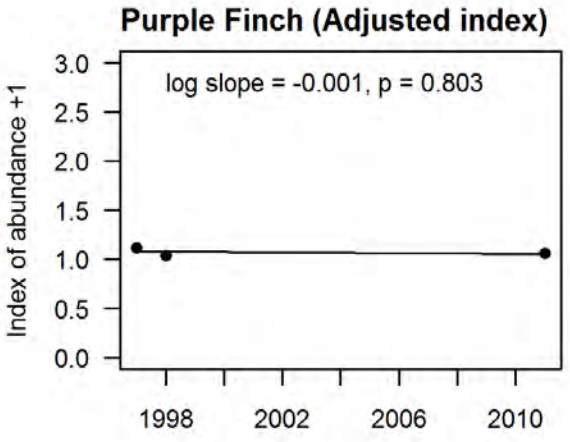

Common Yellowthroat
log slope = -0.025, p = 0.329
Index of abundance
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1998
2002
2006
2010


Wilson's Warbler
log slope = 0, p = 0.994
Index of abundance
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1998
2002
2006
2010


Black-headed Grosbeak
log slope = -0.007, p = 0.861
Index of abundance
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1998
2002
2006
2010


Spotted Towhee
log slope = 0.06, p = 0.273
Index of abundance +1
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1998
2002
2006
2010


Song Sparrow
log slope = -0.016, p = 0.235
Index of abundance
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1998
2002
2006
2010


Purple Finch (Adjusted index)
log slope = -0.001, p = 0.803
Index of abundance +1
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1998
2002
2006
2010

Appendix D. Mean number of birds detected per point per visit within 50m for select focal species in PORE, GOGA, and MCOSD riparian point count transects, May to June, 1997 to 2011.

Station	Year	DOWO	OSFL	WEWP	PSFL	WAVI	WESJ	CBCH	BEWR	WREN	AMRO	SWTH	OCWA	COYE	WIWA	BHGR	SPTO	SOSP	PUFI
Arroyo Hondo	1997	0.00	0.00	0.00	0.44	0.17	0.00	0.33	0.17	0.06	0.06	0.94	0.00	0.00	0.94	0.00	0.06	0.78	0.00
	1998	0.00	0.00	0.00	0.92	0.25	0.00	1.00	0.17	0.17	0.42	0.50	0.17	0.00	1.17	0.08	0.00	0.33	0.08
	1999	0.00	0.00	0.00	1.00	0.33	0.17	0.83	0.25	0.33	0.42	1.50	0.00	0.00	1.42	0.42	0.25	2.17	0.25
	2000	0.00	0.08	0.00	0.58	0.08	0.00	0.92	0.00	0.17	0.25	0.67	0.50	0.00	0.58	0.42	0.08	0.42	0.00
	2001	0.08	0.17	0.00	0.00	0.17	0.00	1.50	0.25	0.08	0.17	1.58	0.08	0.00	1.00	0.00	0.00	0.75	0.08
	2002	0.24	0.06	0.00	0.41	0.35	0.24	0.53	0.00	0.00	0.24	0.94	0.29	0.00	0.71	0.06	0.18	0.82	0.06
	2003	0.00	0.42	0.00	1.08	1.00	0.00	0.50	0.00	0.00	0.33	1.92	0.33	0.00	2.67	0.08	0.17	1.42	0.25
	2004	0.00	0.00	0.00	0.22	0.17	0.06	0.11	0.06	0.00	0.11	0.89	0.00	0.00	1.28	0.06	0.17	0.67	0.00
	2005	0.08	0.00	0.00	0.83	0.08	0.00	0.50	0.00	0.17	0.08	0.58	0.25	0.00	1.17	0.08	0.33	0.42	0.00
	2006	0.00	0.17	0.00	1.00	0.33	0.00	0.17	0.00	0.00	0.00	1.33	0.17	0.00	0.83	0.00	0.00	1.33	0.17
	2007	0.00	0.00	0.00	0.50	0.17	0.00	0.17	0.00	0.33	0.50	0.17	0.00	0.00	1.33	0.00	0.17	0.33	0.00
	2008	0.00	0.08	0.00	0.67	0.33	0.00	0.25	0.08	0.17	0.17	1.00	0.42	0.00	0.58	0.00	0.17	0.83	0.00
	2009	0.00	0.08	0.00	0.50	0.33	0.58	1.17	0.00	0.58	0.17	0.67	0.50	0.00	1.00	0.17	0.17	1.00	0.17
	2010	0.00	0.00	0.00	0.83	0.08	0.00	0.33	0.08	0.00	0.17	0.58	0.25	0.00	1.08	0.08	0.00	0.83	0.08
	2011	0.08	0.00	0.00	0.33	0.08	0.00	0.33	0.00	0.00	0.17	1.00	0.25	0.00	1.33	0.00	0.00	1.00	0.00
Lagunitas Creek	1997	0.14	0.00	0.25	0.25	0.56	0.22	0.89	0.11	0.22	0.17	0.67	0.19	0.00	0.72	0.28	0.14	1.36	0.14
	1998	0.00	0.00	0.08	0.08	0.50	0.03	0.69	0.06	0.11	0.17	0.75	0.08	0.00	0.67	0.47	0.14	1.14	0.00
	1999	0.02	0.00	0.24	0.31	0.67	0.04	0.48	0.02	0.09	0.17	0.76	0.24	0.00	0.81	0.46	0.04	1.48	0.02
	2000	0.04	0.00	0.19	0.15	0.78	0.17	0.57	0.04	0.07	0.24	0.61	0.26	0.00	0.89	0.56	0.07	1.61	0.15
	2001	0.09	0.02	0.44	0.24	1.24	0.19	0.70	0.09	0.20	0.46	1.72	0.22	0.00	1.20	0.43	0.11	1.61	0.26
	2002	0.06	0.02	0.31	0.24	1.30	0.13	0.94	0.44	0.15	0.11	1.33	0.20	0.00	1.48	0.91	0.17	2.31	0.19
	2003	0.09	0.02	0.11	0.33	1.44	0.09	0.87	0.17	0.15	0.13	1.09	0.26	0.00	1.46	0.78	0.41	2.11	0.17
	2004	0.00	0.00	0.22	0.19	0.69	0.19	0.61	0.06	0.11	0.19	0.92	0.17	0.00	0.86	0.31	0.36	1.14	0.00
	2005	0.00	0.00	0.08	0.28	0.67	0.08	0.56	0.03	0.03	0.11	0.58	0.17	0.00	1.08	0.42	0.08	0.92	0.03
	2006	0.00	0.00	0.20	0.14	0.34	0.06	0.51	0.09	0.03	0.06	0.74	0.06	0.00	0.77	0.54	0.23	1.26	0.00

Station	Year	DOWO	OSFL	WEWP	PSFL	WAVI	WESJ	CBCH	BEWR	WREN	AMRO	SWTH	OCWA	COYE	WIWA	BHGR	SPTO	SOSP	PUFI
	2007	0.00	0.00	0.22	0.14	0.47	0.08	0.36	0.06	0.00	0.03	0.72	0.08	0.00	0.86	0.36	0.19	1.31	0.00
	2008	0.00	0.00	0.28	0.22	0.50	0.14	0.78	0.17	0.14	0.03	0.86	0.11	0.00	0.86	0.22	0.25	1.31	0.00
	2009	0.06	0.00	0.19	0.31	0.44	0.14	0.53	0.14	0.22	0.19	1.19	0.11	0.00	0.78	0.42	0.42	0.94	0.00
	2010	0.06	0.00	0.28	0.19	0.67	0.03	0.67	0.08	0.11	0.22	1.17	0.19	0.00	0.94	0.25	0.36	1.14	0.11
	2011	0.08	0.03	0.25	0.19	0.67	0.03	0.53	0.25	0.17	0.00	1.00	0.42	0.00	1.19	0.42	0.36	1.22	0.08
Muddy Hollow	1997	0.15	0.12	0.29	0.47	0.35	0.24	0.15	0.29	0.09	0.29	2.15	0.44	0.35	1.82	0.18	0.38	2.56	0.03
	1998	0.21	0.12	0.21	0.26	0.15	0.06	0.18	0.32	0.00	0.21	0.91	0.24	0.15	1.00	0.24	0.06	1.88	0.03
	1999	0.00	0.13	0.16	0.04	0.09	0.07	0.20	0.20	0.04	0.16	0.67	0.22	0.33	0.67	0.20	0.07	1.51	0.02
	2000	0.11	0.13	0.36	0.02	0.11	0.20	0.16	0.22	0.16	0.13	1.49	0.09	0.31	0.62	0.18	0.29	1.73	0.02
	2001	0.16	0.11	0.42	0.11	0.07	0.18	0.20	0.56	0.44	0.16	2.11	0.13	0.29	0.71	0.36	0.76	2.09	0.09
	2002	0.09	0.33	0.16	0.07	0.09	0.33	0.20	0.96	0.11	0.31	1.91	0.24	0.38	1.16	0.31	0.60	2.82	0.09
	2003	0.02	0.11	0.22	0.11	0.13	0.11	0.31	0.18	0.29	0.09	0.91	0.27	0.11	0.62	0.27	0.49	1.76	0.00
	2004	0.04	0.04	0.04	0.04	0.02	0.18	0.24	0.33	0.13	0.13	0.91	0.04	0.18	0.53	0.13	0.31	1.27	0.00
	2005	0.10	0.10	0.00	0.20	0.07	0.27	0.33	0.27	0.13	0.30	0.97	0.17	0.13	0.60	0.17	0.13	1.20	0.00
	2006	0.07	0.10	0.00	0.03	0.13	0.20	0.23	0.20	0.27	0.00	0.67	0.27	0.27	0.53	0.07	0.30	1.30	0.00
	2007	0.03	0.07	0.03	0.20	0.07	0.10	0.43	0.23	0.33	0.23	1.17	0.33	0.13	1.00	0.17	0.37	1.33	0.03
	2008	0.00	0.10	0.00	0.13	0.07	0.20	0.27	0.27	0.10	0.13	1.50	0.27	0.40	0.63	0.13	0.03	1.47	0.10
	2009	0.03	0.03	0.03	0.23	0.13	0.20	0.53	0.20	0.20	0.13	1.37	0.27	0.30	0.90	0.03	0.13	1.37	0.13
	2010	0.03	0.00	0.03	0.33	0.23	0.03	0.57	0.07	0.17	0.10	1.17	0.23	0.30	0.77	0.07	0.13	1.30	0.03
	2011	0.03	0.00	0.10	0.13	0.13	0.27	0.53	0.37	0.17	0.27	0.77	0.23	0.30	0.80	0.03	0.20	1.43	0.03
Pine Gulch	1997	0.27	0.00	0.00	0.13	0.20	0.07	0.80	0.00	0.47	0.00	1.07	0.00	0.20	1.33	0.53	0.00	1.60	0.00
	1998	0.07	0.00	0.00	0.20	0.20	0.00	0.07	0.00	0.80	0.07	0.67	0.20	0.27	1.00	0.27	0.00	1.73	0.00
	1999	0.07	0.00	0.00	0.00	0.27	0.00	0.53	0.00	0.27	0.13	0.73	0.00	0.27	0.80	0.07	0.00	1.27	0.00
	2000	0.00	0.00	0.00	0.10	0.00	0.00	0.50	0.00	0.30	0.00	1.60	0.00	0.70	1.60	0.60	0.00	2.40	0.10
	2001	0.10	0.00	0.00	0.10	0.60	0.00	0.70	0.10	0.80	0.10	1.90	0.10	0.90	0.40	0.40	0.00	1.60	0.00
	2002	0.07	0.00	0.00	0.60	0.20	0.00	0.60	0.13	0.40	0.00	1.53	0.00	0.67	1.20	0.33	0.00	1.73	0.13
	2003	0.20	0.00	0.00	0.27	0.93	0.00	1.27	0.00	0.40	0.33	2.07	0.20	0.07	1.33	0.13	0.00	3.27	0.20
	2004	0.47	0.00	0.00	0.73	1.40	0.00	1.13	0.07	0.33	0.20	3.27	0.00	0.27	1.53	0.60	0.00	2.73	0.00
	2005	0.40	0.00	0.00	0.40	0.80	0.00	0.90	0.10	0.00	0.00	1.10	0.00	0.20	0.90	0.10	0.00	1.40	0.00
	2006	0.10	0.00	0.00	0.00	0.50	0.00	0.60	0.00	0.20	0.00	1.50	0.00	0.20	0.70	0.00	0.00	1.80	0.00

Station	Year	DOWO	OSFL	WEWP	PSFL	WAVI	WESJ	CBCH	BEWR	WREN	AMRO	SWTH	OCWA	COYE	WIWA	BHGR	SPTO	SOSP	PUFI
	2007	0.40	0.00	0.00	0.10	0.30	0.10	1.00	0.00	0.70	0.00	1.90	0.00	0.60	1.40	0.00	0.20	2.10	0.00
	2008	0.30	0.00	0.00	0.60	0.20	0.10	1.00	0.00	0.60	0.00	0.80	0.00	0.40	1.00	0.10	0.00	1.40	0.00
	2009	0.00	0.00	0.00	0.00	0.20	0.10	0.80	0.00	0.40	0.20	0.90	0.00	0.40	1.20	0.20	0.10	1.50	0.00
	2010	0.00	0.00	0.00	0.70	1.30	0.00	1.00	0.30	0.30	0.00	1.80	0.00	0.00	1.50	0.00	0.00	2.80	0.20
	2011	0.20	0.00	0.00	0.30	0.40	0.00	0.70	0.70	0.40	0.10	1.50	0.00	0.20	0.90	0.00	0.00	1.90	0.00
Redwood Creek	1997	0.21	0.00	0.00	0.06	0.24	0.06	0.62	0.03	0.06	0.15	0.68	0.26	0.00	1.12	0.15	0.06	1.38	0.00
	1998	0.02	0.00	0.02	0.08	0.08	0.04	0.48	0.02	0.00	0.29	0.90	0.06	0.00	0.75	0.15	0.06	1.04	0.06
	1999	0.04	0.01	0.03	0.07	0.21	0.11	0.83	0.10	0.15	0.28	0.75	0.21	0.00	0.83	0.38	0.08	1.47	0.03
	2000	0.10	0.04	0.08	0.13	0.32	0.04	1.04	0.01	0.11	0.28	1.13	0.19	0.04	0.90	0.39	0.08	1.81	0.11
	2001	0.26	0.06	0.08	0.10	0.24	0.18	0.76	0.11	0.17	0.56	2.06	0.18	0.03	1.47	0.32	0.25	2.33	0.25
	2002	0.17	0.06	0.03	0.10	0.26	0.11	0.89	0.15	0.03	0.33	1.29	0.39	0.03	1.49	0.64	0.25	3.06	0.07
	2003	0.06	0.03	0.01	0.11	0.19	0.06	0.88	0.14	0.04	0.17	0.76	0.17	0.03	0.89	0.22	0.07	1.68	0.06
	2004	0.14	0.07	0.00	0.16	0.16	0.09	0.45	0.02	0.05	0.11	0.93	0.20	0.07	0.59	0.36	0.02	1.30	0.00
	2005	0.17	0.04	0.00	0.19	0.33	0.13	0.48	0.06	0.06	0.15	1.02	0.35	0.06	0.75	0.27	0.08	1.23	0.10
	2006	0.02	0.02	0.00	0.10	0.35	0.06	0.52	0.02	0.13	0.13	0.69	0.23	0.04	0.81	0.21	0.04	1.23	0.00
	2007	0.13	0.04	0.00	0.19	0.21	0.08	0.58	0.08	0.04	0.02	1.06	0.21	0.10	0.94	0.33	0.13	1.13	0.02
	2008	0.17	0.04	0.06	0.23	0.27	0.13	0.81	0.04	0.15	0.13	1.17	0.25	0.02	0.98	0.44	0.23	1.23	0.06
	2009	0.23	0.00	0.02	0.21	0.27	0.13	0.75	0.02	0.13	0.08	1.00	0.29	0.08	0.85	0.35	0.08	1.17	0.06
	2010	0.02	0.04	0.02	0.31	0.52	0.06	0.48	0.06	0.17	0.08	0.77	0.35	0.04	1.21	0.44	0.15	1.08	0.10
	2011	0.04	0.00	0.02	0.40	0.38	0.04	0.79	0.00	0.06	0.25	1.08	0.13	0.04	1.13	0.23	0.19	1.63	0.17
Abbotts Kehoe	1997	0.02	0.00	0.00	0.00	0.00	0.17	0.00	0.15	0.69	0.00	0.69	0.00	0.60	0.35	0.00	0.00	2.60	0.08
	1998	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.09	0.19	0.00	0.53	0.00	0.38	0.31	0.00	0.00	2.56	0.03
	2011	0.00	0.00	0.00	0.00	0.00	0.31	0.00	0.13	0.44	0.00	0.63	0.00	0.44	0.63	0.00	0.22	1.97	0.00
Bear Valley	1997	0.04	0.00	0.13	0.23	0.85	0.17	0.65	0.10	0.31	0.27	1.02	0.06	1.00	0.98	0.15	0.13	1.85	0.23
	1998	0.25	0.00	0.38	0.69	1.00	0.13	0.63	0.06	0.25	0.06	1.81	0.00	1.50	1.50	0.69	0.06	2.56	0.06
	2011	0.06	0.00	0.19	0.44	0.69	0.19	0.69	0.16	0.22	0.22	0.97	0.09	0.44	1.00	0.28	0.38	1.25	0.03
Coast Camp	1997	0.00	0.00	0.00	0.13	0.00	0.06	0.00	0.25	0.13	0.00	0.63	0.13	0.00	1.06	0.00	0.69	2.06	0.00
	1998	0.00	0.13	0.00	0.00	0.00	0.08	0.00	0.38	0.13	0.00	0.46	0.54	0.00	0.75	0.21	0.42	2.00	0.04
	2011	0.00	0.00	0.00	0.00	0.00	0.38	0.88	0.69	0.44	0.00	0.63	0.50	0.00	0.56	0.00	0.50	0.75	0.00
Coast Trail	1997	0.08	0.08	0.23	0.31	0.12	0.08	0.23	0.27	0.31	0.35	2.00	0.23	1.31	1.35	0.19	0.23	1.96	0.04

Station	Year	DOWO	OSFL	WEWP	PSFL	WAVI	WESJ	CBCH	BEWR	WREN	AMRO	SWTH	OCWA	COYE	WIWA	BHGR	SPTO	SOSP	PUFI
Laguna	1998	0.10	0.05	0.05	0.21	0.18	0.08	0.21	0.18	0.03	0.23	0.38	0.31	0.56	0.85	0.05	0.05	1.46	0.03
	2011	0.04	0.00	0.00	0.31	0.23	0.04	0.27	0.15	0.12	0.35	0.92	0.42	0.31	0.77	0.12	0.15	0.81	0.00
Gerbode	1997	0.00	0.00	0.00	0.00	0.00	0.15	0.37	0.17	0.61	0.05	0.32	0.34	0.29	0.34	0.07	0.27	1.32	0.15
	1998	0.00	0.00	0.00	0.00	0.02	0.17	0.46	0.26	0.48	0.11	0.52	0.15	0.33	0.70	0.15	0.22	1.20	0.00
	2011	0.03	0.00	0.00	0.00	0.00	0.17	0.53	0.42	0.75	0.00	0.78	0.31	0.47	0.75	0.06	0.61	0.97	0.08
Lower Olema Creek	1997	0.07	0.02	0.07	0.38	0.29	0.24	0.42	0.00	0.51	0.04	1.00	0.02	0.20	1.04	0.07	0.09	1.51	0.27
	1998	0.03	0.00	0.00	0.17	0.07	0.07	0.40	0.00	0.33	0.07	0.67	0.00	0.07	1.10	0.00	0.03	1.37	0.03
	2011	0.05	0.00	0.00	0.14	0.05	0.14	0.68	0.14	0.36	0.00	0.50	0.45	0.14	0.91	0.14	0.45	1.32	0.14
M Ranch	1997	0.00	0.00	0.00	0.00	0.00	0.13	0.25	0.50	0.50	0.00	2.63	0.25	0.63	1.38	0.00	0.13	2.13	0.38
	1998	0.00	0.00	0.00	0.00	0.00	0.33	0.46	0.13	0.33	0.00	0.63	0.29	0.17	0.88	0.04	0.00	1.38	0.04
	2011	0.19	0.00	0.06	0.00	0.19	0.50	0.44	0.31	0.13	0.19	0.63	0.25	0.13	0.94	0.00	0.00	1.06	0.00
Tennessee Valley	1997	0.00	0.00	0.00	0.00	0.00	0.27	0.23	0.15	0.38	0.04	0.54	0.12	0.15	0.62	0.15	0.15	0.85	0.00
	1998	0.07	0.11	0.07	0.07	0.07	0.21	0.46	0.36	0.11	0.18	0.29	0.21	0.36	0.68	0.32	0.32	1.11	0.07
	2011	0.08	0.00	0.00	0.04	0.00	0.23	0.62	0.54	0.46	0.04	0.77	0.31	0.42	0.31	0.12	0.50	1.04	0.08
Upper Olema Creek	1997	0.00	0.00	0.12	0.19	0.54	0.31	0.38	0.15	0.23	0.12	1.31	0.00	0.04	0.69	0.08	0.08	1.54	0.19
	1998	0.00	0.00	0.15	0.12	0.27	0.04	0.27	0.19	0.35	0.04	0.77	0.00	0.04	0.65	0.12	0.04	1.42	0.12
	2011	0.12	0.00	0.04	0.19	0.31	0.04	0.54	0.27	0.35	0.00	0.92	0.08	0.19	0.96	0.19	0.27	1.46	0.04

Supplement A. R code used in analyses.

See accompanying Word document, SFAN_Landbirds_2012_SupplementA_20140129.docx, which shows the R programming code used for all analyses herein.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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National Park Service
U.S. Department of the Interior

Natural Resource Stewardship and Science
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

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