

The 2018-19 Report of the Monitoring Avian Productivity and Survivorship (MAPS) Program on the Audubon Canyon Ranch Cypress Grove Preserve



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Introduction

Audubon Canyon Ranch (ACR) Cypress Grove Preserve, on the eastern shore of Tomales Bay, CA (Figure 1), provides a mosaic of tidal, wetland, and upland habitats supporting a wide diversity of land, sea and shorebirds. ACR maintains an active program of research and management on the avifauna and other wildlife of the region, and has an interest in monitoring trends of local landbirds.

Birds are excellent indicators of habitat quality and environmental change and their diurnal nature and relative abundance in terrestrial ecosystems make them relatively easy and cost-efficient to monitor and capture. Over the past several decades the Monitoring Avian Productivity and Survivorship (MAPS) program has helped land managers understand the ecology of local landbird populations in order to better plan their conservation while in the process becoming one of the nation's largest and geographically most extensive community science programs. With its emphasis on avian vital rates such as productivity and annual survival, MAPS provides information about which life stage is the strongest driver of population change, and where conservation can be carried out most effectively.

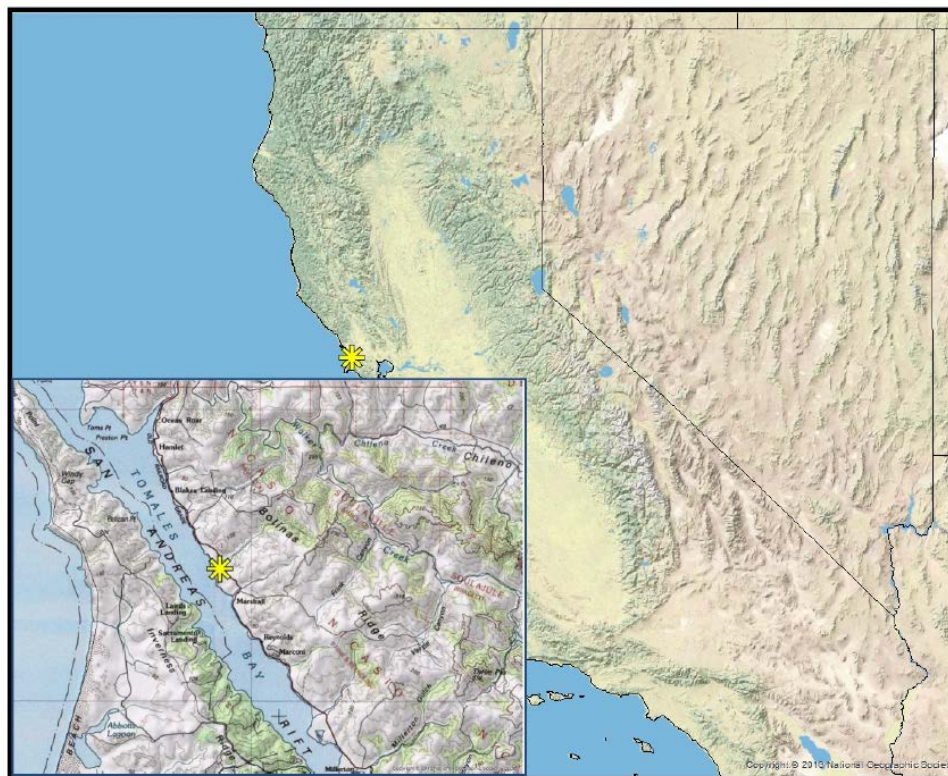


Figure 1. Location of the ACR Cypress Grove Preserve on Tomales Bay.

Methods

In 2015, with the support of the ACR, The Institute for Bird Populations re-established a MAPS station at Livermore Marsh, on the Research Center property. The station had run previously in 2003-05. However, because we were not able to determine the precise locations of the previous net lanes all locations were considered new. Here we report results from 2018-19 (Table 1).

Table 1. Summary of MAPS operations 2018-19.

Station Name:	Livermore Marsh
Habitat Type:	California coastal willow riparian
Latitude:	38°10'13"N
Longitude:	-122°53'58"W
Avg. Elev.:	4 meters ASL
Net-hours:	2018: 434.3 2019: 388.0
Periods run:	2018: 9 2019: 9
Dates:	2018: 8 May-1 Aug 2019: 14 May-2 Aug

The station was operated for approximately six hours per day beginning at about local sunrise, approximately every ten days between May 8 and August 5 (in 2018) and May 14 and August 2 (in 2019). Ten 12.0-meter long, 2.5-meter high, 30-mm mesh nylon mist nets were erected on each day of that station's operation.

With few exceptions, all birds captured were identified to species, age, and sex. Birds were banded with numbered aluminum bands and the following data were collected:

- capture code (newly banded, recaptured, band changed, unbanded)
- band number
- species, age and how it was aged
- sex (if possible) and how sexed (if applicable)
- extent of skull pneumaticization (skull closure, an indicator of age)
- breeding condition of adults (extent of cloacal protuberance or brood patch)
- extent of juvenal plumage in young birds, or the presence of molt limits
- extent of body and flight-feather molt, and primary feather wear
- wing chord
- fat class and body mass

If a situation arose where bird safety could become compromised, such as in adverse weather, nets were closed early and birds were released immediately. Observations of potential breeding behavior for birds around the station were recorded on each day of operation and the final breeding status (confirmed breeder, likely breeder, non-breeder) of each species seen, heard, or captured at the station was recorded at the end of the season.

Data entry and verification

All data were carefully vetted during which we hand-proofed capture code, band number, species, age, sex, date, capture time, station, and net number against raw data and corrected any computer-entry errors. All banding data were run through a series of automated verification programs to verify and cross-check all data with discrepancies corrected as necessary.

Data analysis

We classified species captured based upon their breeding or summer residency status:

- Regular breeder (B) if there was probable evidence of breeding or summer residency with the station boundaries *during all years* the station operated.
- Usual breeder (U) if there was probable evidence of breeding or summer residency within the station boundaries *during more than half but not all years* the station operated.
- Occasional breeder (O) if there was probable evidence of breeding or summer residency within the station boundaries *during half or fewer of the years* the station operated.
- Transient (T) if the species was *never* a breeder or summer resident at the station, but the station was within the overall breeding range of the species.
- Migrant (M) if the station was not located within the species' breeding range.

Data from the station were included in productivity analyses if the station was within the breeding range of the species; that is, data were included where the species was a breeder (B, U, or O), or transient (T), but not where the species was a migrant (M). Data for a given species were included in survivorship or trend analyses only if the species was breeder (B) or regular breeder (U).

Adult population index and productivity analyses

Capture rates were normalized to the number of captures per 600 net-hours -- a standard unit of effort across the continental MAPS program which allows for comparison among years and stations. Post-fledging productivity was estimated by the ratio of individual young birds (hatch-year birds, or HYs) to adult birds, which were categorized as after hatch-year birds (AHYs) including second year birds (SYs), and after-second year birds (ASYs). We calculated the following metrics for each species:

- Number of newly banded birds, recaptured birds, and birds released unbanded.
- The numbers and capture rates (per 600 net-hours) of first captures in a given year of individual adult and young birds.
- The reproductive index (the ratio of young per adult of a given species).

Trends in adult population index

We examined trends in adult population size and productivity index using regression analysis. We present the slope, the standard error (SE) of the slope, the correlation coefficient (r), and the significance of the correlation (p) to describe each trend. Unbanded birds were not included in the indices of adult or young population indices, or productivity.

Mark-recapture survivorship analyses

Survival was estimated using Modified Cormack-Jolly-Seber mark-recapture analyses on the five years (2015 to 2019). No operation of LIVE took place in 2017. Survival was estimated for species for which, on average, at least 2.5 individual adult new captures per year and at least two between-year recaptures were recorded. We used the software program MARK and the RMark package in R to calculate, for each species, maximum-likelihood estimates and standard errors for adult survival probability, adult recapture probability, and the proportion of residents among newly captured adults using a time-constant, transient model. The use of the transient model accounts for the existence of transient adults (dispersing and floater individuals which are only captured once) in the sample of newly captured birds, and provides survival estimates that are unbiased with respect to these transient individuals. Recapture probability is defined as the conditional probability of recapturing a bird in a subsequent year that was banded in a previous year, given that it survived and returned to the station where it was originally banded. Survivorship cannot be estimated until a minimum of four years of data have been

collected, with a maximum of two years of missed sampling between each year of sampling. Typically, five years are required to obtain sufficient numbers of year-to-year returns upon which to base survivorship calculations with sufficient precision to meaningfully interpret, and additional years substantially increase the precision of the values.

Results and Discussion

The MAPS station at Cypress Grove has operated intermittently for seven years starting in 2003 (Table 2). Over this period, 2,085 birds of 40 species were captured, and the overall adult population was estimated at 159 individual birds in the area encompassed by the MAPS station (Table 3).

Table 2. Summary of Effort and Captures

Year	Net Hours	Captures
2003	525.33	358
2004	489.00	245
2005	521.33	350
2015	434.00	297
2016	460.67	281
2018	434.33	257
2019	388.00	297

Table 3. Mean numbers of aged individual birds captured per 600 net-hours and reproductive index averaged over the 7 years of station operation.

Species	Total Captures	Adult Popn. Size	Reproductive Index
Mourning Dove	6	0.0	0.0
Anna's Hummingbird	6	0.0	0.0
Rufous Hummingbird	1	0.0	0.0
Allen's Hummingbird	34	0.0	0.0
Virginia Rail	1	1.1	0.0
Downy Woodpecker	15	1.8	0.5
Nuttall's Woodpecker	1	1.5	0.0
Hairy Woodpecker	1	0.0	0.0
Ash-throated Flycatcher	1	0.0	0.0
Olive-sided Flycatcher	1	1.1	0.0
Pacific Slope Flycatcher	56	4.7	1.7
Black Phoebe	1	0.0	0.0
Hutton's Vireo	14	2.1	0.1
Cassin's Vireo	1	0.0	0.0
Warbling Vireo	10	1.3	0.0
California Scrub-Jay	7	2.3	0.0
Tree Swallow	2	2.3	0.0
Barn Swallow	4	2.3	0.0
Chestnut-backed Chickadee	88	6.2	2.1
Bushtit	21	4.4	1.3
Brown Creeper	7	1.4	0.0
Marsh Wren	3	1.8	0.0
Bewick's Wren	114	7.3	1.3
Wrentit	210	12.5	1.0
Swainson's Thrush	471	32.6	0.4
American Robin	16	3.0	0.6
House Finch	3	0.0	0.0
Purple Finch	4	1.9	0.0
American Goldfinch	66	10.3	0.0
Spotted Towhee	28	3.9	0.4
California Towhee	11	2.2	0.1
Song Sparrow	415	27.1	1.0
Brown-headed Cowbird	14	2.2	0.0
Orange-crowned Warbler	40	5.6	1.5
Common Yellowthroat	137	12.6	0.5
American Redstart	2	0.0	0.0
Wilson's Warbler	265	21.7	1.0
Black-headed Grosbeak	7	1.9	0.3
Lazuli Bunting	1	1.1	0.0
ALL SPECIES POOLED	2085	159.1	0.7

¹ Numbers of adults per 600 net hours or reproductive index may fall to zero if the species is infrequently captured each year because all values are averaged.

2019 Indices of Adult Population Size and Post-Fledging Productivity

Numbers of newly-banded, unbanded, and recaptured birds remained relatively constant for 2018-19 (Table 3): 257 captures (142 new captures, 113 recaptures) of 21 species in 2018 and 297 captures (187 new captures, 110 recaptures) of 22 species in 2019. The greatest number of captures in both years were recorded for Wilson's Warbler, Song Sparrow, Swainson's Thrush, Chestnut-backed Chickadee, Common Yellowthroat, and Wrentit, though numbers shifted slightly between years.

Captures per 600 net-hours (rather than absolute numbers) are shown in Table 4 so data can be compared between years which, for logistical and weather reasons, have had different degrees of capture effort. The overall Reproductive Index (number of young captured per adult) was 0.41 in 2018 and 0.65 in 2019, with the highest index for both years recorded for Chestnut-Backed Chickadee in 2018 and Wilson's Warbler in 2019.

Table 4. Capture numbers by species (first three columns in each year); and adults and young per 600 net hours with proportion of young (last three columns for each year) for 2018 and 2019. N=Newly Banded, U=Unbanded, R=Recaptures of banded birds; Ad=Adult birds per 600 net hours; Yg=Juvenile birds per 600 net hours; Prop Yg=The proportion of young:adult.

	2018						2019					
	N	U	R	Ad.	Yg.	Prop. Yg.	N	U	R	Ad.	Yg.	Prop. Yg.
Mourning Dove							2					
Anna's Hummingbird		1										
Rufous Hummingbird		1										
Allen's Hummingbird		3					5					
Downy Woodpecker	1		1	2.8	0	0	1			1.5	0	0
Nuttall's Woodpecker							1			1.5	0	0
Pacific Slope Flycatcher	8		4	6.9	5.5	0.8	7		1	7.7	3.1	0.4
Hutton's Vireo			1	1.4	0	0	1	1		1.5	0	0
Warbling Vireo							1			1.5	0	0
Chestnut-backed Chickadee	13		1	8.3	9.7	1.17	11	1	5	12.4	7.7	0.63
Bushtit	4			5.5	0	0						
Brown Creeper	1			1.4	0	0	4			0	6.2	und. ¹
Bewick's Wren	6	1	4	9.7	1.4	0.14	8		9	12.4	4.6	0.38
Wrentit	10		16	13.8	5.5	0.4	23		13	26.3	12.4	0.47
Swainson's Thrush	15		37	27.6	5.5	0.2	31		26	34	23.2	0.68
American Robin	1			1.4	0	0						
Purple Finch							1			1.5	0	0
American Goldfinch	4	1		5.5	0	0	7	3		10.8	0	0
Spotted Towhee	5		3	8.3	0	0	6			6.2	3.1	0.5
California Towhee			2	1.4	0	0						
Song Sparrow	25	1	18	29	11.1	0.38	36	3	21	34	34	1
Brown-headed Cowbird	1		1	2.8	0	0	1		1	1.5	0	0
Orange-crowned Warbler	5			2.8	4.1	1.5	5		4	10.8	1.5	0.14
Common Yellowthroat	12		7	18	1.4	0.08	11	1	7	13.9	7.7	0.56
American Redstart							1					
Wilson's Warbler	31	1	11	23.5	24.9	1.06	29		6	20.1	27.8	1.39
Black-headed Grosbeak							2		1	3.1	0	0
Total	142	9	106	169.9	69.1	0.41	187	16	94	201	131.4	0.65
Total Number of Captures		257						297				
Total Number of Species		21						22				

¹Reproductive index (young/adult) is undefined because no adults of this species were captured in this year.

Although the station has been run intermittently since 2003, data were robust enough to estimate population trends for twelve species (Figure 2). Six of the twelve species analyzed had statistically-significant population increases: Pacific-slope Flycatcher, Chestnut-backed Chickadee, Bewick's Wren, Wrentit, Spotted Towhee, and Orange-crowned Warbler. One species, American Goldfinch, had a statistically significant population decline. Five species had no significant trend in population, though trends were generally increasing: Song Sparrow, Bushtit, Swainson's Thrush, Common Yellowthroat, and Wilson's Warbler. All species pooled showed a highly statistically-significant population increase.

Interestingly, productivity trended downward for ten of the twelve species examined, though the trend was significant only for Wrentit and Orange-crowned Warbler. Reasons for the decline in productivity are not clear.

Adult apparent survival rates (Table 5) were calculated for the period 2015-2019 for five species with large enough sample sizes: Swainson's Thrush (0.618), Spotted Towhee (0.932), Song Sparrow (0.588), Common Yellowthroat (0.199), and Wilson's Warbler (0.638).

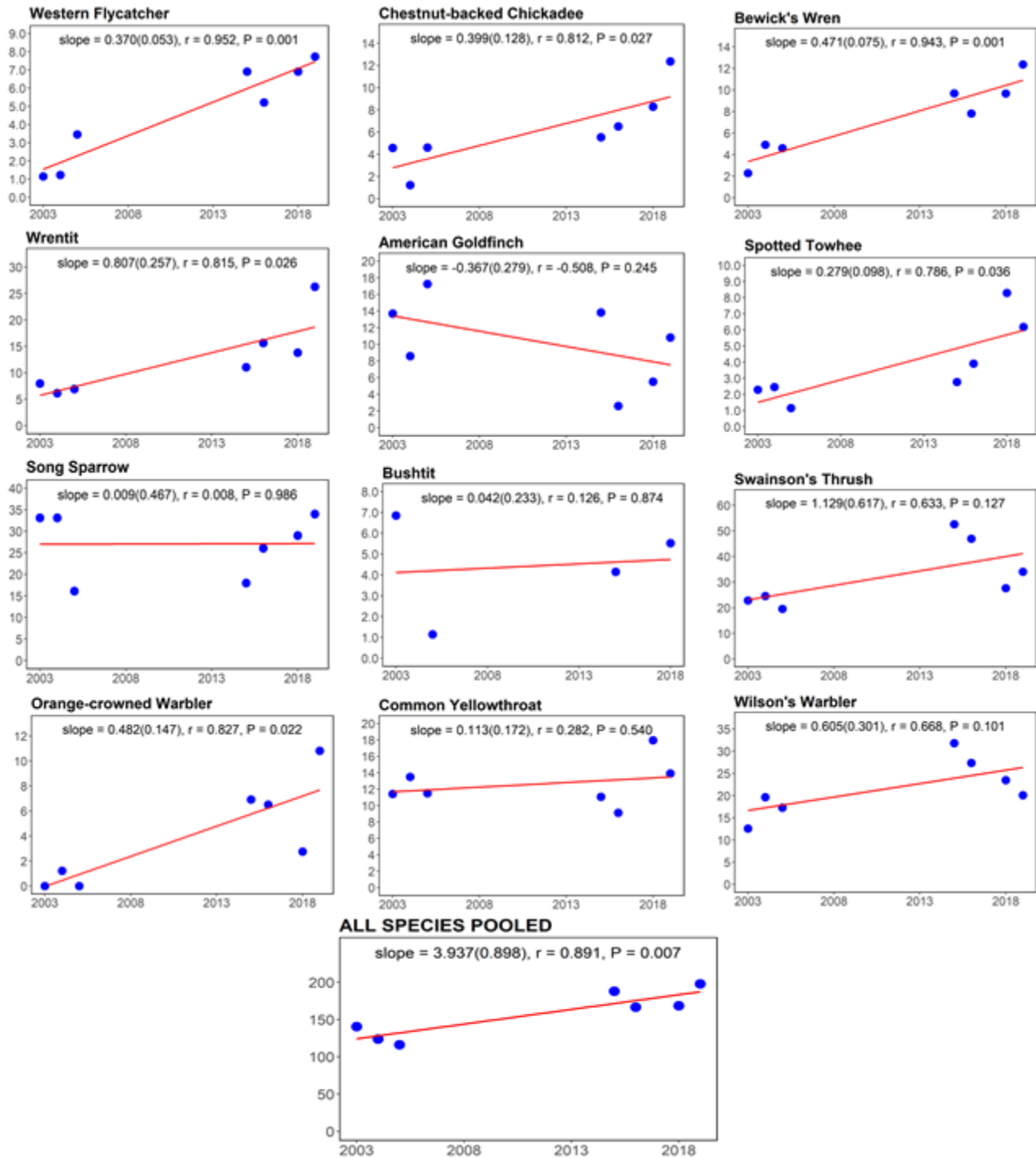


Figure 2. Population trends with standard error (parenthesis) for 12 species and all species pooled, 2003-2019 (stations ran in 2003-05, 2015-16, and 2018-19)). The index of population size (y-axis) is the # of adults captured per 600 net-hours for each year for species that are regular or usual breeders. Linear regression of population size was used as the measure of the population trend (red line). The correlation coefficient (r) and significance of the correlation coefficient (P) are also shown for each species. A negative r-value indicates a declining population, and a P-value of < 0.05 is statistically significant.

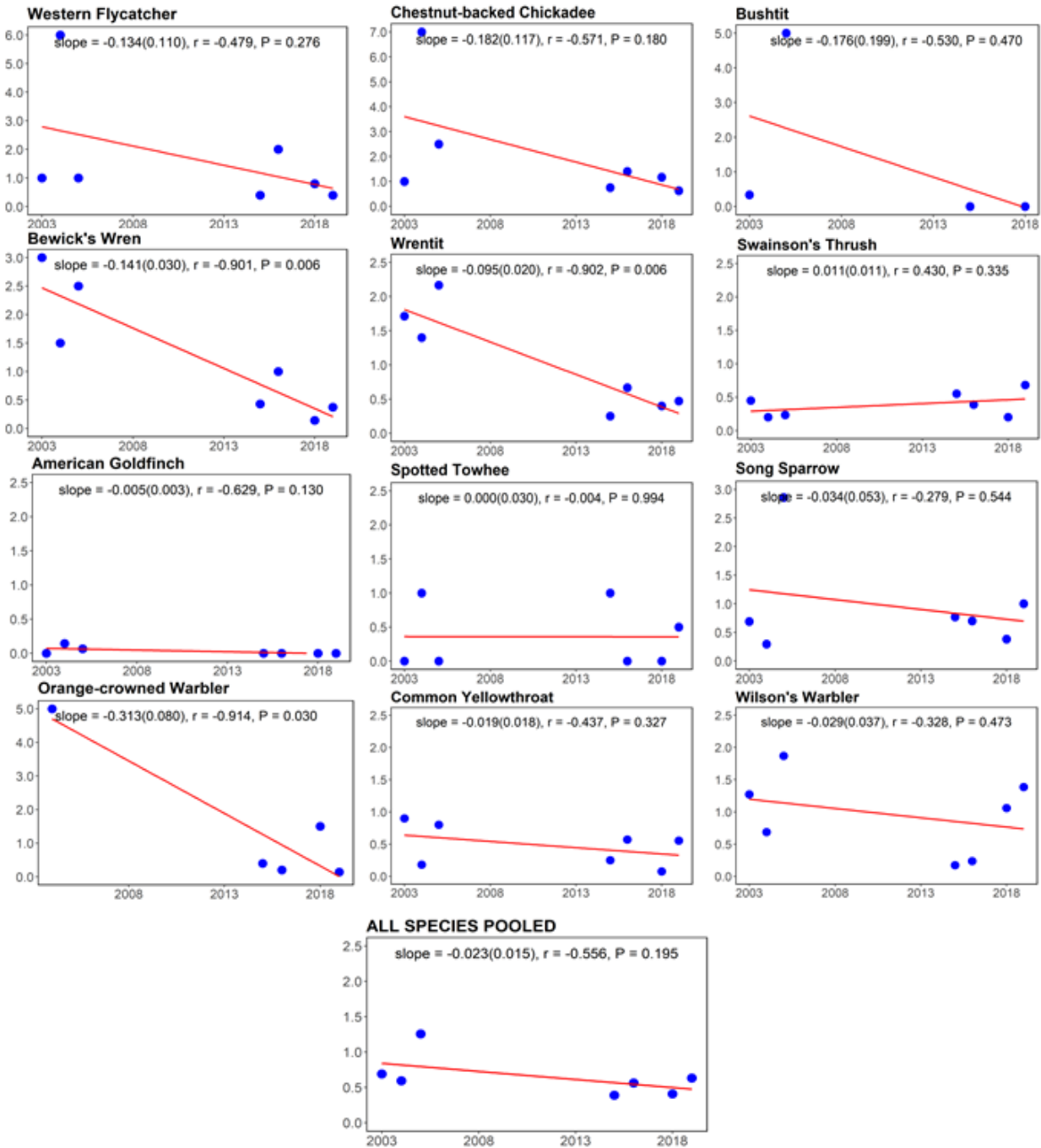


Figure 3. Trend in productivity and standard error (in parenthesis) for 12 species and all species pooled at Cypress Grove Preserve, 2003-2019. The reproductive index was calculated as the productivity (young per adult) for each year, for species categorized as a regular or usual breeders. The regression line (red) for annual change in the index of productivity was used as the measure of the productivity trend. The correlation coefficient (r) and significance of the correlation coefficient (p) are also shown.

Table 5. Estimates of adult survival and recapture probability and proportion of residents for five species breeding at Cypress Grove Preserve, 2015-2019.

	# of Individuals ¹	# of Returns ²	# of Captures ³	Survival Probability and SE ⁴		Surv. CV ⁵	Recapture Prob. ⁶ and SE		Proportion of Residents ⁷	
Swainson's Thrush	86	30	235	0.618	0.068	11.0	0.804	0.112	0.332	0.134
Spotted Towhee*	13	2	17	0.932	0.832	89.3	0.296	0.352	0.378	0.57
Song Sparrow+	58	18	107	0.588	0.118	20.0	0.560	0.168	1.000	
Common Yellowthroat+	30	7	47	0.434	0.199	45.9	0.315	0.114	1.000	
Wilson's Warbler	61	13	105	0.638	0.136	21.2	0.376	0.169	0.715	0.346

Notes:

- ¹ Number of adult individuals captured where the species was a regular or usual breeder (i.e., number of capture histories).
- ² Total number of returns. A return is the first recapture in a given year of a bird originally banded in a previous year.
- ³ Total number of captures of adult birds of the species where the species was a regular or usual breeder.
- ⁴ Survival probability is the maximum likelihood estimate, with standard error. No survivorship estimates were 25% or more lower than the survivorship estimate for that species derived from the continental MAPS database (DeSante et al. 2015)
- ⁵ The coefficient of variation for survival probability, a $CV(\varphi) \geq 50.0\%$ is considered imprecise.
- ⁶ Recapture probability presented as the maximum likelihood estimate (standard error of the estimate).
- ⁷ The proportion of residents among newly captured adults presented as the maximum likelihood estimate (standard error of the estimate).
- + The estimate for recapture probability (and possibly survival probability as well) may be biased low because the estimate for proportion of residents was 1.000.
- * The estimate for survival probability should be viewed with caution because it is based on five or fewer between-year recaptures or the estimate is very imprecise ($SE(\varphi) \geq 0.200$ or $CV(\varphi) \geq 50.0\%$).

Bird populations continue to decline across North America. Many short-term projects and programs are aimed at tracking population trends, but few offer the depth, breadth, and the ability to look at the proximate causes of population decline as the MAPS Program. The continuation of the MAPS Program at Cypress Grove is an important contribution to the long-term data set, and we look forward to collecting more data in the future to further understand the population ecology of local birds.

Acknowledgments

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Appendix I. Breeding status of species banded or encountered during all years of operation

between 2003-19. Abbreviations: (B=Regular Breeder, all years; U=Usual Breeder (>1/2, not all, years);

O=Occasional Breeder (<1/2 years); T=Transient; M=Migrant.

Species Name	Breeding Status	Species Name	Breeding Status
Canada Goose	T	Pacific-slope Flycatcher	B
Mallard	T	Western Flycatcher	B
American Green-winged Teal	M	Black Phoebe	T
California Quail	U	Hutton's Vireo	U
Wild Turkey	O	Cassin's Vireo	T
Eurasian Collared-Dove	U	Warbling Vireo	T
Mourning Dove	B	California Scrub-Jay	B
Common Nighthawk	M	American Crow	B
Anna's Hummingbird	B	Common Raven	U
Rufous Hummingbird	M	Tree Swallow	U
Allen's Hummingbird	U	Violet-green Swallow	O
Virginia Rail	U	N. Rough-winged Swallow	O
Sora	T	Cliff Swallow	O
Black Oystercatcher	T	Barn Swallow	U
Killdeer	O	Chestnut-backed Chickadee	B
Whimbrel	M	Bushtit	B
Solitary Sandpiper	M	Brown Creeper	T
Ring-billed Gull	M	Marsh Wren	O
Western Gull	T	Bewick's Wren	B
California Gull	M	Wrentit	B
Caspian Tern	T	Western Bluebird	T
Pacific Loon	T	Swainson's Thrush	B
Common Loon	T	American Robin	B
Double-crested Cormorant	T	European Starling	O
American White Pelican	M	Cedar Waxwing	M
Great Blue Heron	U	House Finch	O
Great Egret	U	Purple Finch	U
Snowy Egret	T	Pine Siskin	T
Green Heron	T	Lesser Goldfinch	T
Turkey Vulture	O	American Goldfinch	B
Osprey	O	Spotted Towhee	B
White-tailed Kite	U	California Towhee	B
Northern Harrier	O	Lark Bunting	M
Cooper's Hawk	T	Savannah Sparrow	T
Red-shouldered Hawk	O	Song Sparrow	B
Red-tailed Hawk	O	Hooded Oriole	T
Barn Owl	T	Red-winged Blackbird	O
Western Screech-Owl	T	Brown-headed Cowbird	B
Short-eared Owl	T	Brewer's Blackbird	O
Belted Kingfisher	T	Orange-crowned Warbler	U
Downy Woodpecker	B	MacGillivray's Warbler	M
Nuttall's Woodpecker	O	Common Yellowthroat	B
Hairy Woodpecker	T	American Redstart	M
American Kestrel	T	Yellow Warbler	T
Ash-throated Flycatcher	T	Wilson's Warbler	B
Western Kingbird	T	Black-headed Grosbeak	U
Olive-sided Flycatcher	T	Lazuli Bunting	T
Western Wood-Pewee	T		