



Landbird Monitoring in the Northern Colorado Plateau Network

2018 Field Season

Natural Resource Report NPS/NCPN/NRR—2019/1907



ON THE COVER

Male summer tanager. (U.S. Fish and Wildlife Service/Chelsi Burns)

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Executive Summary

In 2018, the University of Delaware, in cooperation with the National Park Service (NPS), completed the thirteenth year of a habitat-based landbird monitoring program in park units of the Northern Colorado Plateau Network (NCPN). This program is designed to provide rigorous data on population trends for most diurnal, regularly occurring breeding landbird species throughout the network. This population information is useful for land managers and supports the National Park Service's goal of conserving park resources through long-term monitoring of biological indicators.

In 2018, university biologists surveyed 45 locations within 11 NPS units. Fifteen transects were located in each of the three habitats of interest: low-elevation riparian, pinyon-juniper, and sage shrubland. Each location was surveyed once. In addition to the habitat-based surveys, four point counts and an area search were conducted at Pipe Spring National Monument, using a modified monitoring design.

Over 13 years of data collection, 13,618 point-count surveys have been conducted in 11 NCPN units, detecting 167 unique species. During the 2018 field season, 644 point-count surveys were conducted, detecting 103 unique species. One new species was detected for this monitoring program: a summer tanager, during a low-elevation riparian transect survey in Zion National Park.

In total, 135 population-density trends were estimated across the three habitats. Twenty-two of these estimated trends were significant (p -value < 0.05), including 15 negative trends and 7 positive trends. There were sufficient sample sizes to estimate the densities of 64 species in at least one of the three habitats surveyed.

Using a modified monitoring design, landbird monitoring surveys were conducted in Pipe Spring National Monument for the ninth year since 2009. A total of 131 individuals of 40 species were recorded. Three common yellowthroats, a Lincoln's sparrow, and a Cassin's finch were detected for the first time by this monitoring program, and a migrant northern waterthrush was detected for the first time within park boundaries. Sample sizes were too low for density trends to be estimated for Pipe Spring National Monument.

Due to differences in distance sampling methodology, all density estimates in this report should replace those found in reports from previous years.

1 Introduction

Detecting environmental change over broad temporal and spatial scales is an important goal of conservation science, especially in the face of climate change and other major anthropogenic disturbances. Through long-term data collection, valuable ecological information about the causes and consequences of these changes can be gathered and used to inform natural resource management.

Diurnal bird species are commonly used as indicators of environmental health because they are sensitive to environmental change and relatively easy to monitor (Canterbury et al. 2000; Gardali et al. 2006; Gardali and Holmes 2011). Through long-term monitoring of breeding bird populations, we can estimate the population status and trends of individual species and bird communities in specific habitats, thus providing information about changes occurring in the surrounding landscape (Browder et al. 2002; Sauer et al. 2003; Gregory et al. 2007).

In the 2016 Partners in Flight Landbird Conservation Plan, Rosenberg and others (2016) recounted dramatic declines in North American landbird populations, citing an overall reduction of over one billion individual landbirds since 1970. As bird populations decline, establishing and continuing long-term population monitoring is essential to finding causes and solutions for threatened, endangered, and declining populations.

Bird communities that rely on arid habitats, such as sage shrubland, are among the most vulnerable to population declines in an era of warming temperatures and increasing anthropogenic land use (Rosenberg et al. 2016). Habitat loss and degradation due to grazing and agriculture (Fleischner 1994; Rosenberg et al. 2016), the expansion of pinyon-juniper

habitat (Miller and Wigand 1994; Baruch-Mordo et al. 2013), and the widespread threat of drought (Breshears et al. 2005) are among the major threats to arid landscapes and their inhabitants (Rosenberg et al. 2016). Public lands support more than half the breeding range of 36 aridland-obligate species in the U.S. and Canada (Rosenberg et al. 2016), but threats of habitat loss and degradation remain. Concerted monitoring efforts are important for conserving bird communities in these areas.

In 2018, the University of Delaware, in cooperation with the National Park Service (NPS), completed the thirteenth year of a habitat-based landbird monitoring program in NPS units of the Northern Colorado Plateau Network (NCPN). Starting in 2005, surveys for the NCPN landbird monitoring program were completed annually for 11 consecutive years by the Bird Conservancy of the Rockies (BCR), with a hiatus in 2016. In 2017, the University of Delaware resumed the monitoring.

The NCPN landbird monitoring program is designed to provide managers of 11 national parks in Colorado, Utah, and Wyoming with long-term population trend data for breeding birds in three habitats: low-elevation riparian, pinyon-juniper, and sage shrubland. Using modified methods, monitoring is also conducted at Pipe Spring National Monument (NM), in Arizona.

In this report, we use distance-sampling analysis to evaluate long-term density trends of all bird species present (with sufficient sample sizes) in the three focal habitats throughout the NCPN. In future analyses, we will evaluate the driving landscape and climate variables affecting long-term, transect-level bird population trends.

2 Methods

2.1 Study area and sampling design

Three habitats were selected for NCPN landbird monitoring when the program was established in 2005: low-elevation riparian (LR), pinyon-juniper (PJ), and sage shrubland (SA). Even with some overlap, each of these habitats hosts a distinct suite of bird species. Across 11 NPS units (Figure 2-1), 45 transect locations were selected, with 15 transects established in each habitat. Each transect consists of 15 point-count locations, each 250 meters apart (Figures 2-2 to 2-4).

The NPS and BCR used GIS and the Southwest Regional GAP Analysis Project to randomly select PJ and SA transect locations (Lowry et al. 2005). Within those habitats, they excluded areas with >50% slope to ensure that each transect could be accessed on foot. Because of the scarcity of riparian habitat in the NCPN, LR transect locations were manually selected. Sites with crossable streams were chosen, excluding the Colorado, Green, Gunnison, and Virgin rivers. Transects were groundtruthed and reasigned if necessary.

Since 2005, all 45 transects have remained in place and represent the annually scheduled surveys for this program. From 2005 to 2013, field teams surveyed each transect twice annually. Starting in 2014, survey effort was reduced to one visit per year. The number of completed surveys has varied by year, with >75% of planned surveys completed annually (Table 2-1).

In 2009, Pipe Spring National Monument was added to the monitoring program. However, due to the park's small size, only four point-count locations were established, each at least 250 meters apart (Figure 2-5). These point-count locations were placed in a mixture of pinyon-juniper, low-elevation riparian, and semi-desert shrubland habitats. In 2011, to increase bird monitoring efforts in the park, a 1,200-meter area-search transect was added to the program.

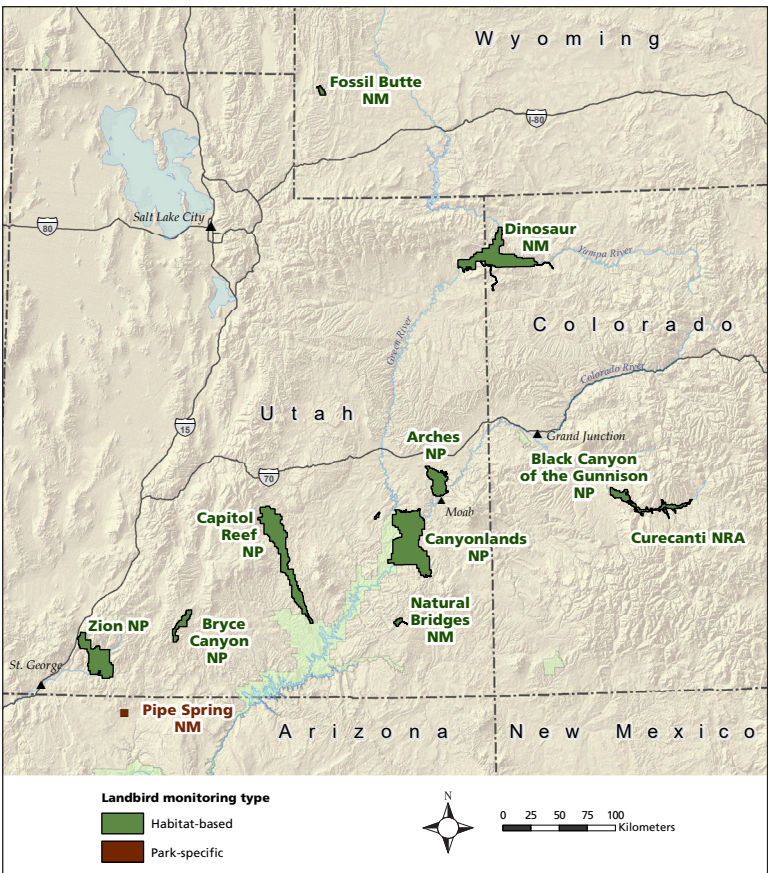


Figure 2-1. Northern Colorado Plateau Network parks where landbirds are monitored.

Table 2-1. Annual number of point visits within each habitat (when possible, points were visited twice from 2005 to 2013).

Year	Low-elevation riparian	Pinyon-juniper	Sage shrubland
2005	439	450	441
2006	443	443	450
2007	449	447	450
2008	450	415	420
2009	381	409	401
2010	389	432	441
2011	408	390	435
2012	371	422	444
2013	326	337	398
2014	153	167	206
2015	158	153	196
2017	225	210	225
2018	220	201	223

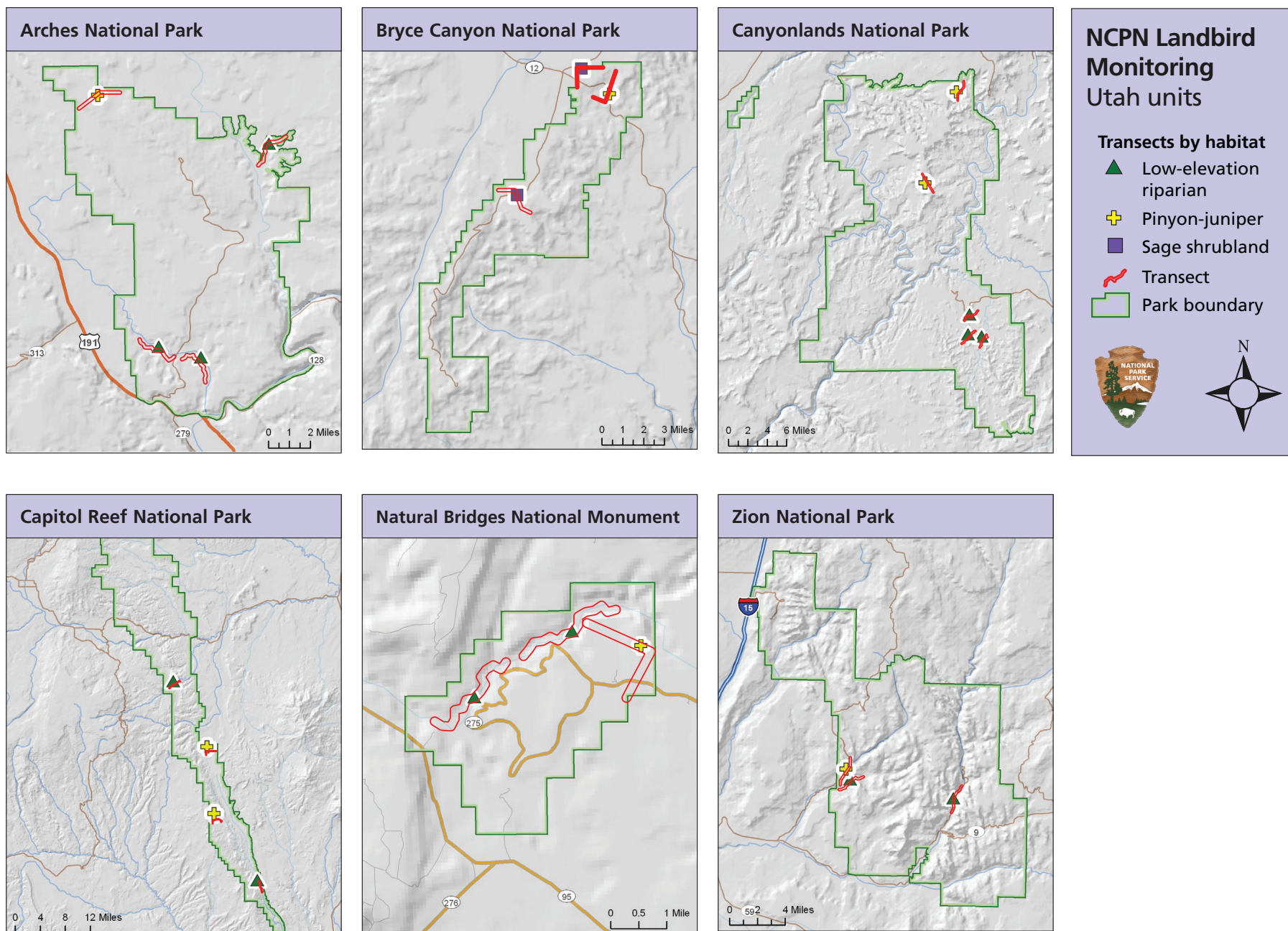


Figure 2-2. Transect locations by habitat, Utah units.

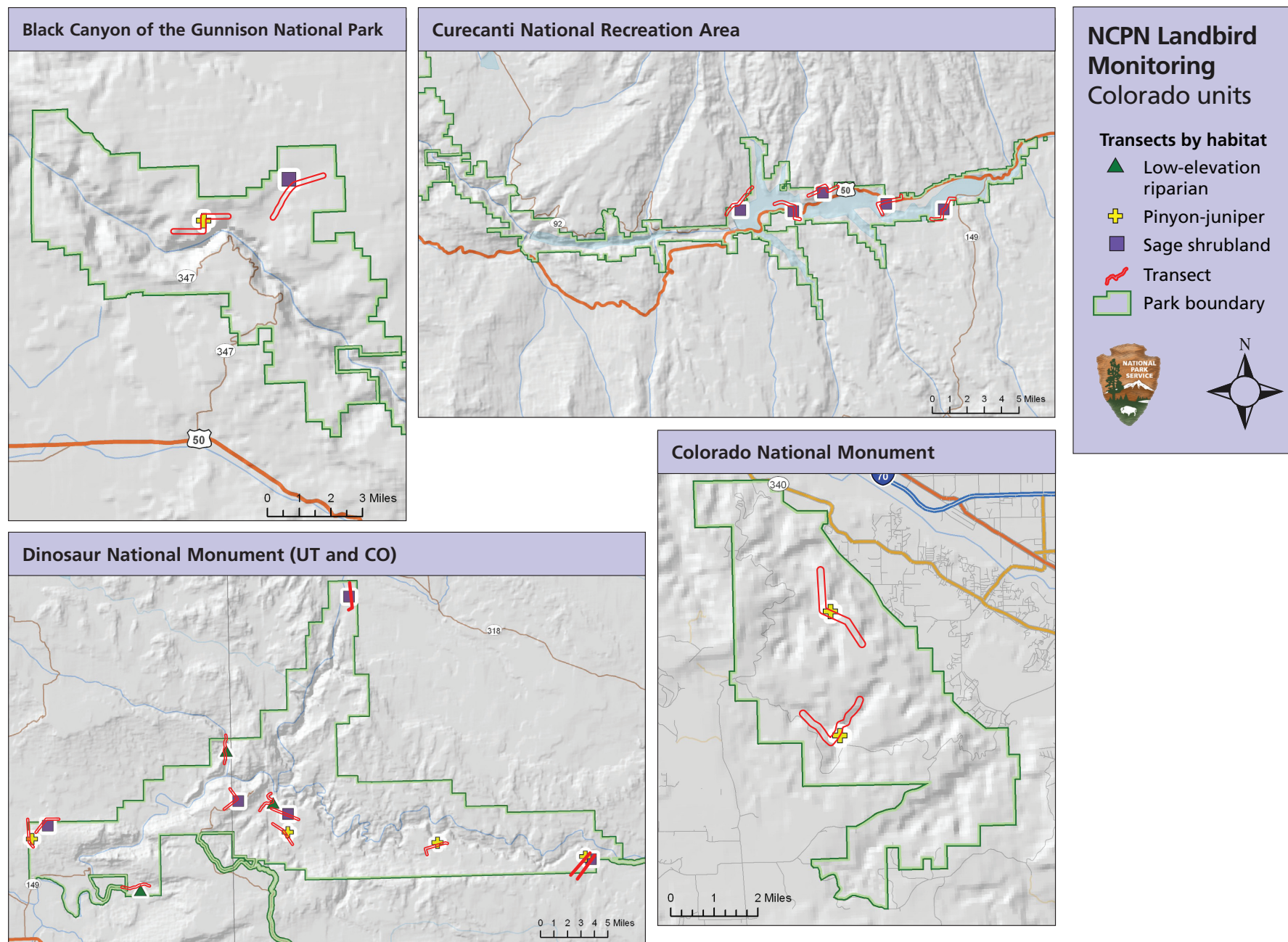


Figure 2-3. Transect locations by habitat, Colorado units.

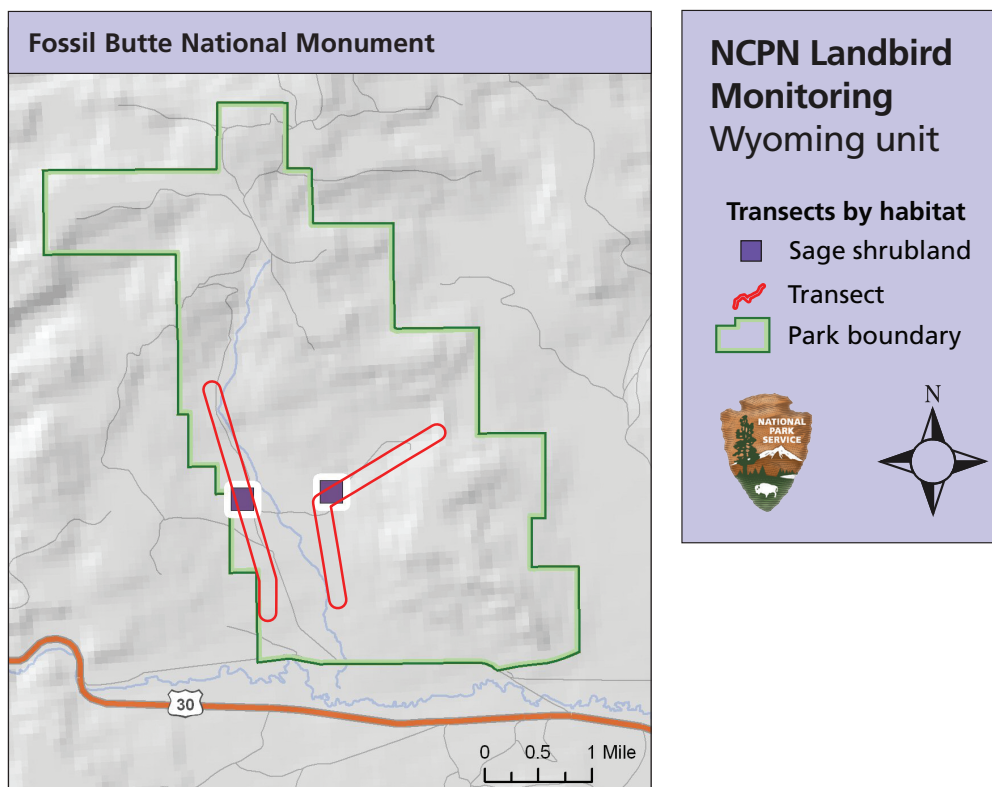


Figure 2-4. Transect locations, Fossil Butte National Monument.

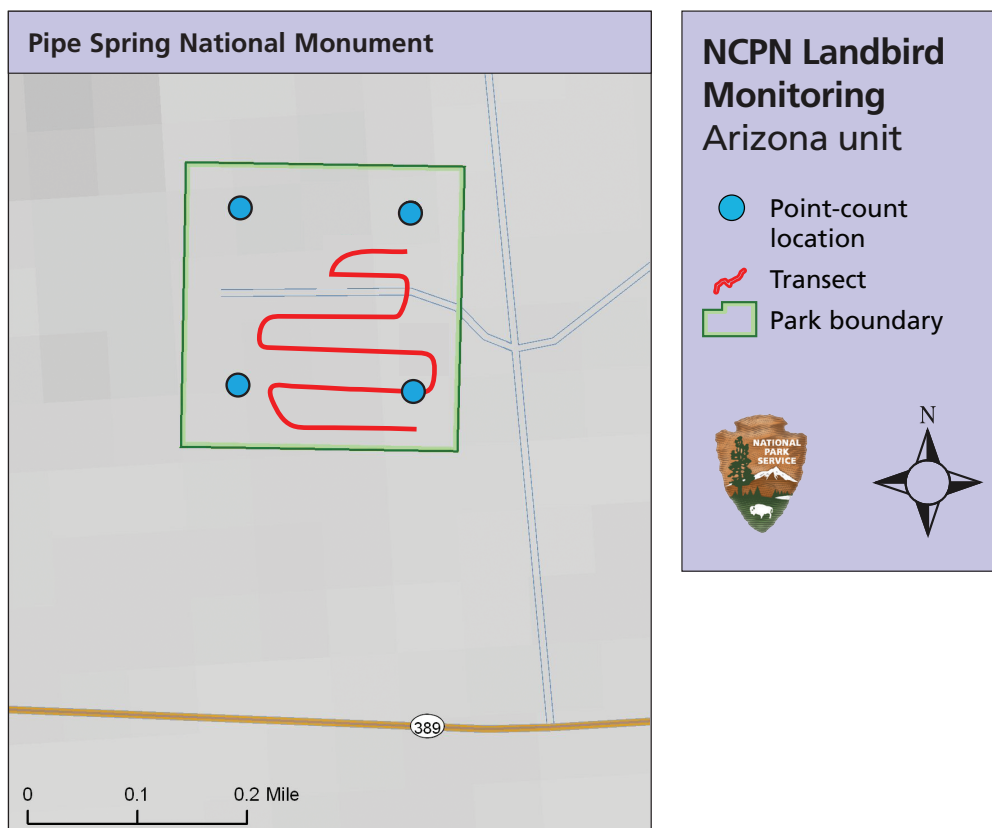


Figure 2-5. Point-count and area-search locations, Pipe Spring National Monument.

2.2 Field methods

Each year, field technicians attend a week-long training session to practice bird and plant identification, review field protocols, and hone distance-estimation skills (see Section 2.3.1). All transects are completed during the breeding season, which occurs between May 1 and July 15, depending on transect location. The elevation and latitudinal position of each transect are considered during the scheduling of each field season. The goal is to survey transects during the peak breeding season at each location.

Observers complete one transect per day, beginning within 30 minutes of sunrise and ending within five hours. Navigating to each point using a GPS unit, observers walk the transect, stopping at each of 15 point-count stations to record weather data, conduct a habitat assessment, and complete a five-minute point count.

At the beginning and end of each transect, observers record the following weather data: temperature, percent cloud cover, precipitation type, and estimated wind speed using the Beaufort scale. Surveys are not conducted if winds exceed 13–18 mph or precipitation is heavier than a drizzle.

During habitat assessments, observers record the overstory seral stage, canopy cover, mean height, and relative abundance of the five most-dominant tree or shrub species. Observers also record the seral stage, volume, mean height, and relative abundance of the five most-dominant species in the understory layer. Groundcover data and the presence of additional, non-dominant habitat types are also recorded.

During the five-minute point count, observers record all bird detections, regardless of distance to the observer. For each detection, observers record species, sex, horizontal distance to the bird, method of detection (visual, call, song, or other), and, if applicable, the number of birds within a cluster. Clusters are defined as groups of conspecific birds in close proximity to each other that are not considered as separate independent observations. The exact distance to each bird or cluster of birds is estimated using a laser

range-finder. Observers also record flyovers, defined as individuals or clusters that are detected during the point counts but are not using the immediate surrounding landscape.

During the walk between point-count stations, observers record detections of low-density and difficult-to-detect species as a method of bolstering the sample sizes for these groups.

Habitat assessments and point counts at Pipe Spring NM follow the methods described above. In addition, observers continuously walk the 1,200-meter area-search transect during the time remaining after completing the point counts, recording the same data for all bird detections as are collected during point counts.

For more detailed information about survey protocols, refer to Daw and others (2017) and BCR's Northern Colorado Plateau Network Point Transect Protocol on the Rocky Mountain Avian Data Center website, <http://rmbo.org/v3/avian/DataCollection.aspx>. Links to past and current protocols and data-sheets may also be found at that site.

2.3 Data analysis

2.3.1 Distance sampling

We used the “Distance” package in program R (version 3.1.3; RCoreTeam 2014), which utilizes Distance 6.2 (Thomas et al. 2010) to estimate detection probabilities and bird population densities. Distance sampling relies on three main assumptions, which we met using established field protocols and training:

1. All objects at the sampling location are detected,
2. Objects are stationary or detected before movement occurs, and
3. Distances to objects are measured accurately.

In distance sampling, the distribution of observed distances of objects depends on the actual distribution of objects with respect to the observer, and the detectability of an object. As such, detection functions must first be fit to distance-sampling data to describe

the probability of detection of an object. The selected detection function is then used to estimate an average probability of detection, which allows for observed counts to be corrected and used for density estimation.

2.3.2 *Habitat-based density trends*

Our initial analysis focused on estimating densities within each of the three habitat types for the full range of species present. We excluded flyovers, migrants, and juveniles from our analyses. With survey locations only 250 meters apart, there can be double-counting of individuals from multiple points. To avoid including double-counted individuals in our analyses, we set a cut-off distance of 125 meters, only including detections within this distance in our analyses.

To ensure sufficient sample sizes, we only estimated densities of species for which there were at least 80 independent detections within a habitat across all years within the distance cut-off. For each eligible species

within a habitat each year, we fit a series of five pre-selected detection function models to the distribution of distances observed:

1. Uniform function with cosine series adjustments,
2. Half normal key function with no adjustments,
3. Half normal key function with cosine series adjustments,
4. Half normal key function with “observer” as a covariate, and
5. Hazard rate key function with cosine series adjustments.

We ranked models using Akaike’s Information Criterion (AIC), selecting the top model as the most parsimonious detection function for each species (Burnham and Anderson 2002). We used the top detection function for each species in each habitat in each year to estimate density. We then fit a simple linear model to the annual densities for each species to determine trend direction and significance.

3 Results

Over 13 years of data collection, 13,618 point-count surveys have been conducted in 11 NCPN units (see Table 2-1), detecting 167 unique species. Of those 167 species, 151 were within 125 meters of the observer, the established distance cut-off for our analyses (see Section 2.3.2). In 2018, between May 7 and June 25, field technicians completed 44 of 45 planned habitat-based transects, for a total of 644 point-count surveys. A total of 5,678 individual birds of 103 unique species were recorded. One new species was detected for this monitoring program: a summer tanager, during a low-elevation riparian transect survey in Zion National Park.

3.1 Habitat-based density trends

We excluded density estimates with a detection probability coefficient of variance of >100 . We had sufficient sample sizes to es-

timate the densities of 64 species in at least one of the three habitats surveyed. In total, we estimated 135 population density trends across the three habitats. Twenty-two of the estimated density trends were significant (p -value <0.05), including 15 negative trends and 7 positive trends (Table 3-1).

3.2 Pipe Spring National Monument summary

In 2018, we completed all four point-count surveys and the area search at Pipe Spring National Monument. We detected a total of 131 individuals of 40 species during surveys (Table 3-2). Three common yellowthroats, a Lincoln's sparrow, and a Cassin's finch were detected for the first time by this monitoring program. A migrant northern waterthrush was detected for the first time within park boundaries. Sample sizes were too low for density trends to be estimated for Pipe Spring National Monument.

Table 3-1. Population-density trend slope, R² values, and sample size of estimated annual densities for individual species in low-elevation riparian, pinyon-juniper, and sagebrush shrubland habitats in the Northern Colorado Plateau Network, 2005–2015 and 2017–2018.

Common name	Low-elevation riparian			Pinyon-juniper			Sage shrubland		
	Slope ^a	R ²	Sample size ^b	Slope ^a	R ²	Sample size ^b	Slope ^a	R ²	Sample size ^b
Mourning dove	-11.87 ^c	0.72	12	-16.20 ^d	0.41	13	-1.85	0.15	11
White-throated swift	-11.06 ^d	0.37	13	-9.64 ^e	0.56	13	-4.32	0.15	10
Black-chinned hummingbird	-33.62	0.17	12	1.28	0.00	10	–	–	–
Broad-tailed hummingbird	33.47	0.28	13	-13.53	0.05	9	9.09	0.11	12
Hairy woodpecker	0.13	0.00	10	–	–	–	–	–	–
Northern flicker	1.48	0.25	13	0.15	0.00	11	0.12	0.01	13
Western wood-pewee	0.08	0.00	11	–	–	–	0.09	0.02	12
Gray flycatcher	0.43	0.07	9	-3.69	0.03	13	-0.04	0.00	13
Dusky flycatcher	–	–	–	-2.42	0.03	12	2.09	0.05	13
Black phoebe	-1.99	0.03	13	–	–	–	–	–	–
Say's phoebe	-1.06	0.06	13	-0.57	0.12	10	0.14	0.01	11
Ash-throated flycatcher	-6.35	0.12	13	-3.63	0.17	13	0.35	0.01	11
Gray vireo	-0.38	0.03	12	3.36	0.10	13	–	–	–
Plumbeous vireo	-2.78	0.05	13	1.52	0.06	13	-0.31	0.02	12
Warbling vireo	1.70	0.02	13	–	–	–	0.14	0.00	12
Pinyon jay	–	–	–	-2.01	0.28	13	-0.04	0.01	6
Woodhouse's scrub-jay	-0.17	0.00	13	3.33	0.07	12	-0.17	0.00	11
Black-billed magpie	–	–	–	–	–	–	-1.20	0.19	13
Common raven	-0.83	0.07	13	-0.35	0.10	13	-0.42	0.07	11
Horned lark	–	–	–	–	–	–	0.51	0.01	13
Violet-green swallow	-47.42	0.04	12	3.37	0.03	12	3.09	0.20	12
Cliff swallow	–	–	–	–	–	–	-5.45	0.21	11
Mountain chickadee	–	–	–	1.07	0.02	13	–	–	–
Juniper titmouse	-4.89	0.20	13	-1.03	0.00	12	–	–	–
Bushtit	2.29	0.03	9	-34.99	0.33	11	–	–	–
White-breasted nuthatch	–	–	–	-1.08	0.04	12	–	–	–
Rock wren	-3.67 ^d	0.36	13	-2.08	0.12	12	-2.58 ^d	0.33	13
Canyon wren	0.14	0.00	13	-0.02	0.00	11	–	–	–
House wren	6.22	0.14	13	–	–	–	1.84 ^e	0.52	12
Bewick's wren	-2.69	0.06	13	-8.30	0.24	13	–	–	–
Blue-gray gnatcatcher	20.73	0.04	13	23.71	0.06	13	0.71	0.00	11
Western bluebird	–	–	–	–	–	–	0.07	0.00	11
Mountain bluebird	–	–	–	-3.69	0.26	12	0.81	0.01	13
Hermit thrush	–	–	–	0.84	0.15	8	–	–	–
American robin	-5.20	0.26	12	0.36	0.00	12	-0.54	0.01	13
Sage thrasher	–	–	–	–	–	–	-2.01	0.08	12
Lucy's warbler	12.46	0.11	11	–	–	–	–	–	–

Table 3-1. Population-density trend slope, R^2 values, and sample size of estimated annual densities for individual species in low-elevation riparian, pinyon-juniper, and sage shrubland habitats in the Northern Colorado Plateau Network, 2005–2015 and 2017–2018, cont.

Common name	Low-elevation riparian			Pinyon-juniper			Sage shrubland		
	Slope ^a	R ²	Sample size ^b	Slope ^a	R ²	Sample size ^b	Slope ^a	R ²	Sample size ^b
Virginia's warbler	-1.63	0.03	12	1.61	0.07	11	2.12^d	0.36	13
Common yellowthroat	-4.11	0.03	12	–	–	–	–	–	–
Yellow warbler	10.27	0.04	13	–	–	–	2.52^d	0.52	11
Yellow-rumped warbler	4.38	0.04	12	4.90	0.20	10	-0.49	0.01	11
Grace's warbler	–	–	–	-1.37	0.29	13	-0.60	0.24	13
Black-throated gray warbler	-1.39	0.02	12	-21.49^d	0.32	13	-2.17^d	0.39	11
Yellow-breasted chat	1.03	0.02	12	–	–	–	1.41	0.43	9
Green-tailed towhee	–	–	–	3.79^d	0.43	12	0.46	0.00	13
Spotted towhee	11.26	0.03	13	11.09^d	0.33	13	3.02	0.11	13
Chipping sparrow	-9.61	0.19	11	-0.40	0.00	12	-4.13	0.08	12
Brewer's sparrow	–	–	–	–	–	–	24.11	0.16	13
Vesper sparrow	–	–	–	2.77^e	0.53	12	-3.55	0.03	13
Lark sparrow	0.66	0.02	12	-0.27	0.00	13	5.41	0.25	13
Black-throated sparrow	-1.70	0.01	12	-2.09	0.03	12	1.31	0.12	12
Sagebrush sparrow	–	–	–	–	–	–	-2.11^d	0.38	12
Song sparrow	-8.23	0.17	12	–	–	–	–	–	–
Dark-eyed junco	–	–	–	-1.83^d	0.38	11	–	–	–
Western tanager	1.48	0.11	12	0.08	0.00	12	-0.40	0.22	12
Black-headed grosbeak	-3.46^d	0.44	11	3.89^e	0.55	12	-0.12	0.00	10
Blue grosbeak	2.00	0.03	13	–	–	–	–	–	–
Lazuli bunting	-25.12^d	0.41	12	4.14	0.09	11	0.17	0.00	12
Western meadowlark	–	–	–	-3.09^d	0.49	12	-2.09	0.15	13
Brewer's blackbird	–	–	–	–	–	–	0.77	0.04	13
Brown-headed cowbird	-6.25^d	0.39	11	0.85	0.01	13	-1.48	0.14	13
Bullock's oriole	0.60	0.01	9	–	–	–	–	–	–
House finch	-17.23^e	0.56	12	0.99	0.00	12	-1.78	0.17	12
Lesser goldfinch	-9.09	0.09	12	0.45	0.00	11	–	–	–

^aNo superscript = p-value >0.05

^bSample sizes are the number of years in which densities could be estimated. Models could not be fit for each species-habitat combination for all years due to low detection sample sizes.

^cp-value ≤0.001; ^dp-value ≤0.05; ^ep-value ≤0.01. Values marked with c, d, or e are also bolded and shown in colored text. Positive trends are shown in green. Negative trends are shown in red.

Table 3-2. Number of individuals detected during point counts and area searches in Pipe Spring National Monument, 2009–2015 and 2017–2018.

Species	Point counts		Area searches		Total
	2009–2015	2017–2018	2009–2015	2017–2018	
Mallard	0	0	1	0	1
Mallard (domestic)	0	0	10	0	10
Gambel's quail	45	3	35	3	86
Black-crowned night-heron	1	0	11	0	12
Cooper's hawk	1	0	1	0	2
Red-tailed hawk	1	0	1	0	2
Eurasian collared-dove	50	2	82	3	137
Mourning dove	20	6	37	8	71
Great horned owl	0	0	1	0	1
Common poorwill	0	0	3	0	3
White-throated swift	20	0	3	0	23
Black-chinned hummingbird	2	0	0	0	2
Broad-tailed hummingbird	0	0	4	0	4
Downy woodpecker	1	0	0	0	1
Hairy woodpecker	0	1	1	0	2
American kestrel	5	0	11	0	16
Peregrine falcon	5	0	0	0	5
Prairie falcon	1	0	0	0	1
Western wood-pewee	3	0	7	1	11
Gray flycatcher	1	0	1	1	3
Black phoebe	6	0	18	0	24
Say's phoebe	24	3	24	0	51
Ash-throated flycatcher	25	2	18	1	46
Cassin's kingbird	55	1	35	1	92
Western kingbird	37	1	34	0	72
Gray vireo	5	2	0	2	9
Warbling vireo	0	0	4	0	4
Pinyon jay	1	0	0	0	1
Woodhouse's scrub-jay	3	0	6	1	10
Common raven	38	1	24	1	64
Violet-green swallow	14	0	53	0	67
Northern rough-winged swallow	9	0	4	0	13
Cliff swallow	0	0	1	0	1
Barn swallow	2	0	0	0	2
Juniper titmouse	6	0	1	0	7
Rock wren	21	0	1	2	24
Canyon wren	2	0	0	1	3
House wren	1	0	0	1	2
Bewick's wren	15	4	26	3	48
Blue-gray gnatcatcher	6	1	1	1	9

Table 3-2. Number of individuals detected during point counts and area searches in Pipe Spring National Monument, 2009–2015 and 2017–2018, cont.

Species	Point counts		Area searches		Total
	2009–2015	2017–2018	2009–2015	2017–2018	
American robin	3	0	0	0	3
Northern mockingbird	29	0	4	1	34
Sage thrasher	1	0	0	0	1
European starling	22	0	85	4	111
Cedar waxwing	0	0	2	0	2
Northern waterthrush	0	0	0	1	1
Orange-crowned warbler	0	0	1	1	2
Macgillivray's warbler	1	1	0	0	2
Common yellowthroat	0	0	0	3	3
Yellow warbler	10	1	43	2	56
Yellow-rumped warbler	1	0	3	0	4
Black-throated gray warbler	4	0	1	0	5
Wilson's warbler	0	0	1	2	3
Yellow-breasted chat	0	0	1	0	1
Green-tailed towhee	1	1	3	1	6
Spotted towhee	6	0	0	0	6
Chipping sparrow	1	0	1	0	2
Brewer's sparrow	2	1	0	0	3
Lark sparrow	1	0	21	1	23
Black-throated sparrow	91	2	41	3	137
Lincoln's sparrow	0	0	0	1	1
White-crowned sparrow	14	1	38	2	55
Summer tanager	1	0	0	0	1
Western tanager	2	1	6	1	10
Black-headed grosbeak	6	0	7	3	16
Blue grosbeak	5	0	5	0	10
Lazuli bunting	2	0	6	0	8
Red-winged blackbird	1	0	0	0	1
Western meadowlark	1	0	0	0	1
Yellow-headed blackbird	1	0	1	0	2
Brown-headed cowbird	16	0	16	1	33
Bullock's oriole	28	1	25	2	56
House finch	103	27	90	5	225
Pine siskin	2	0	29	0	31
Lesser goldfinch	10	0	9	1	20
House sparrow	8	0	53	0	61
Total	799	63	951	65	1,878

4 Discussion

As the western landscape continues to change due to anthropogenic land use and climate change, bird populations unable to adapt are at risk for decline. The focal habitats of this study are dominant throughout the western U.S., and are among the most likely to change. With gradual changes affecting habitat integrity for bird populations, such as pinyon-juniper encroachment on sage shrubland (Miller and Wigand 1994; Baruch-Mordo et al. 2013) and increases in regional drought (Breshears et al. 2005), long-term monitoring is essential for detecting gradual shifts in bird populations.

In this report, we present 13-year population-density trends within low-elevation riparian, pinyon-juniper, and sage shrubland habitats for 64 species (a total of 113 species/habitat combinations; Appendix A). The majority of density trend estimates were non-significant, indicating the potential for stable populations for many species.

Of the 135 trend estimates, 22 were significant, with 15 negative trends and 7 positive trends. While this study does not explore specific factors linked to these trends in the NCPN, we provide evidence of long-term regional declines and increases in individual bird populations within these three important habitats. Continued monitoring of these populations will be essential to acquiring significant trend estimates for a larger suite of

species. With each year of additional monitoring, we will also be able to more confidently assess the causes of longer-term changes to bird populations relative to surrounding landscape and climate variables.

It should be noted that because of the nature of low-elevation riparian, pinyon-juniper, and sage shrubland habitat in this region, many transects in this study may contain components of more than one of these three habitat types. For example, all riparian transects in the region are thin strips of riparian vegetation fed by intermittent streams within a matrix of pinyon-juniper or sage shrubland. As such, many species detected within 125 meters of an observer during riparian point counts are not directly using riparian habitat. While species may show significant trends within a specific habitat, caution should be used when interpreting the biological relevance of these trends.

Future studies using these data will seek to estimate population density trends for individual species at the transect level. Transect-level estimates will provide a finer-scale view of population trends to complement the regionwide analyses presented in this report. Using land-cover and climate variables, we will evaluate the drivers of density trends for individual species, allowing us to identify prominent threats to declining species and estimate causes of variance in these trends across the NCPN.

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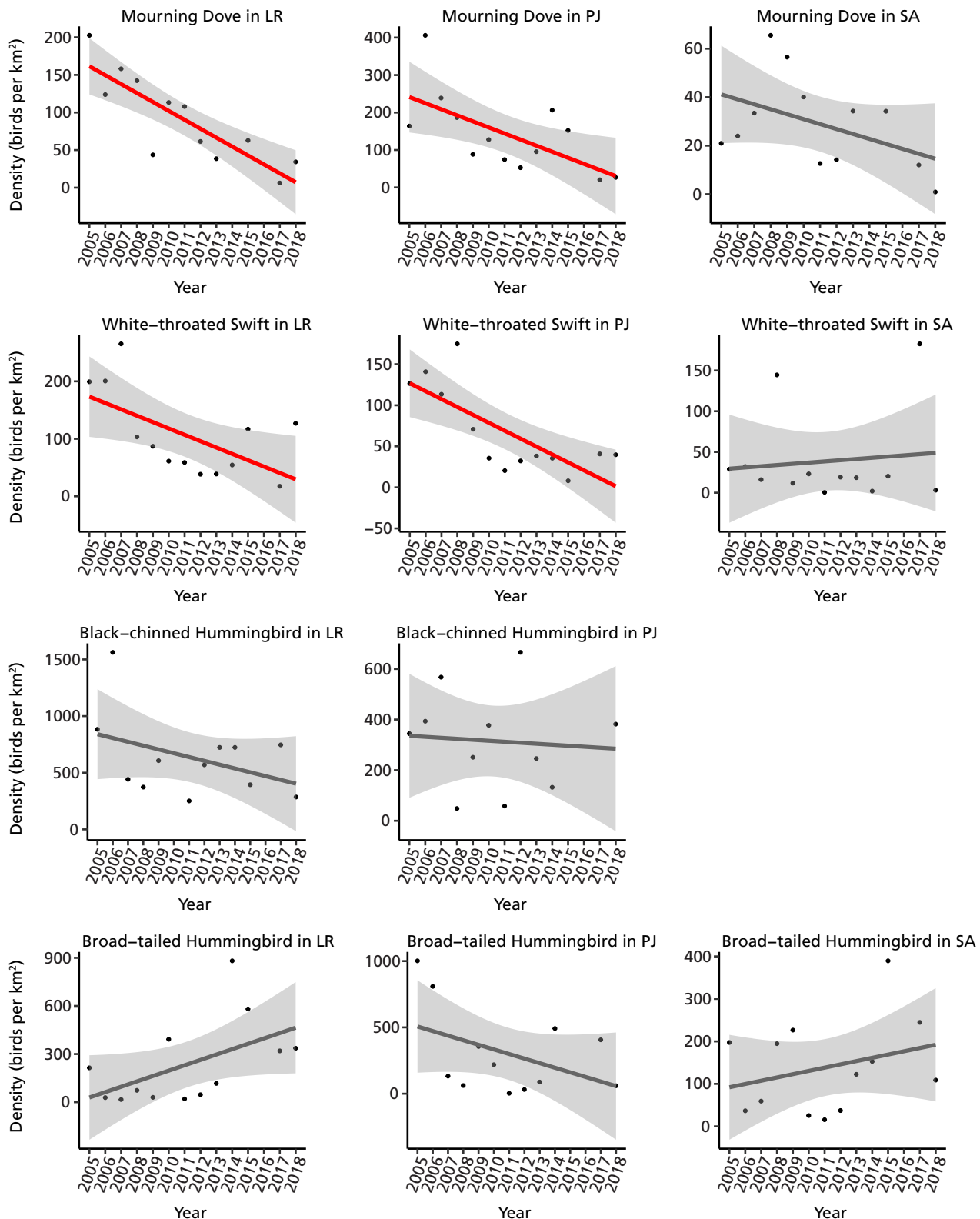
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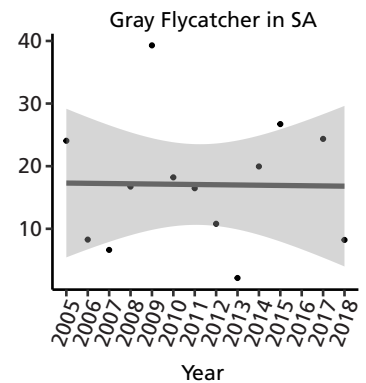
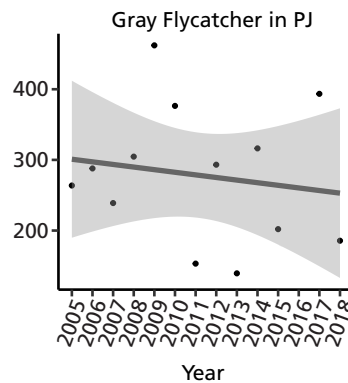
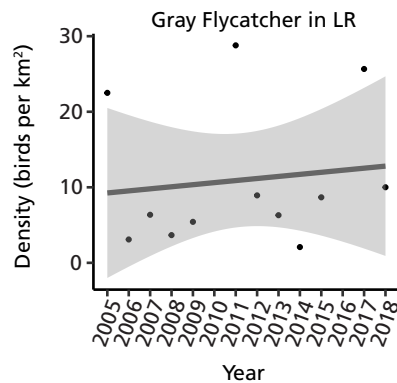
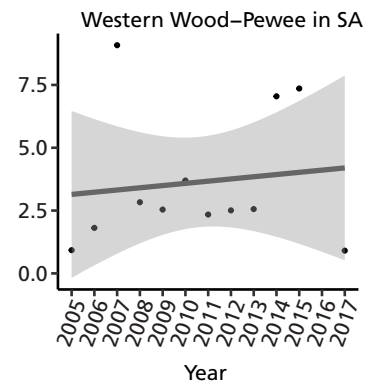
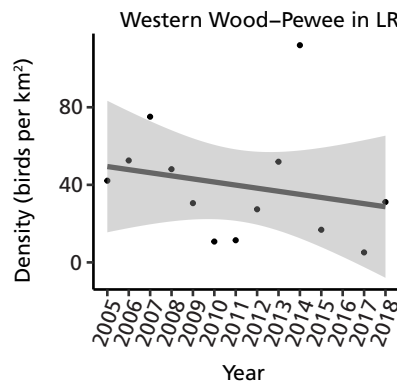
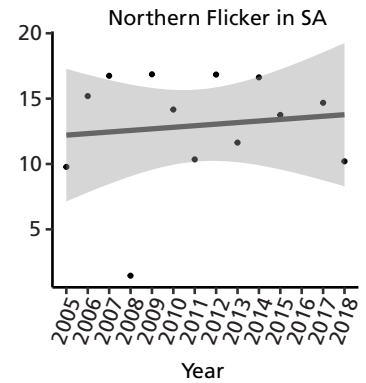
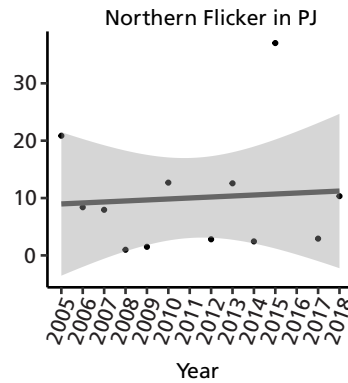
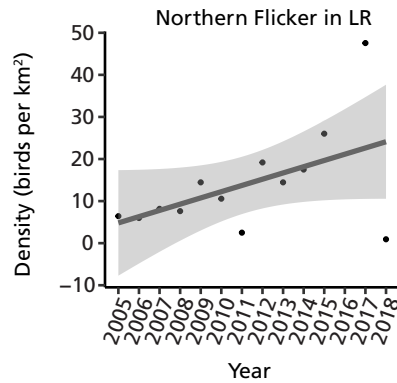
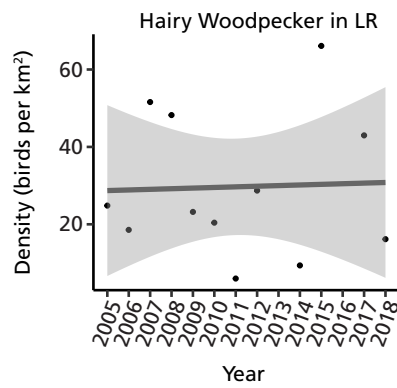
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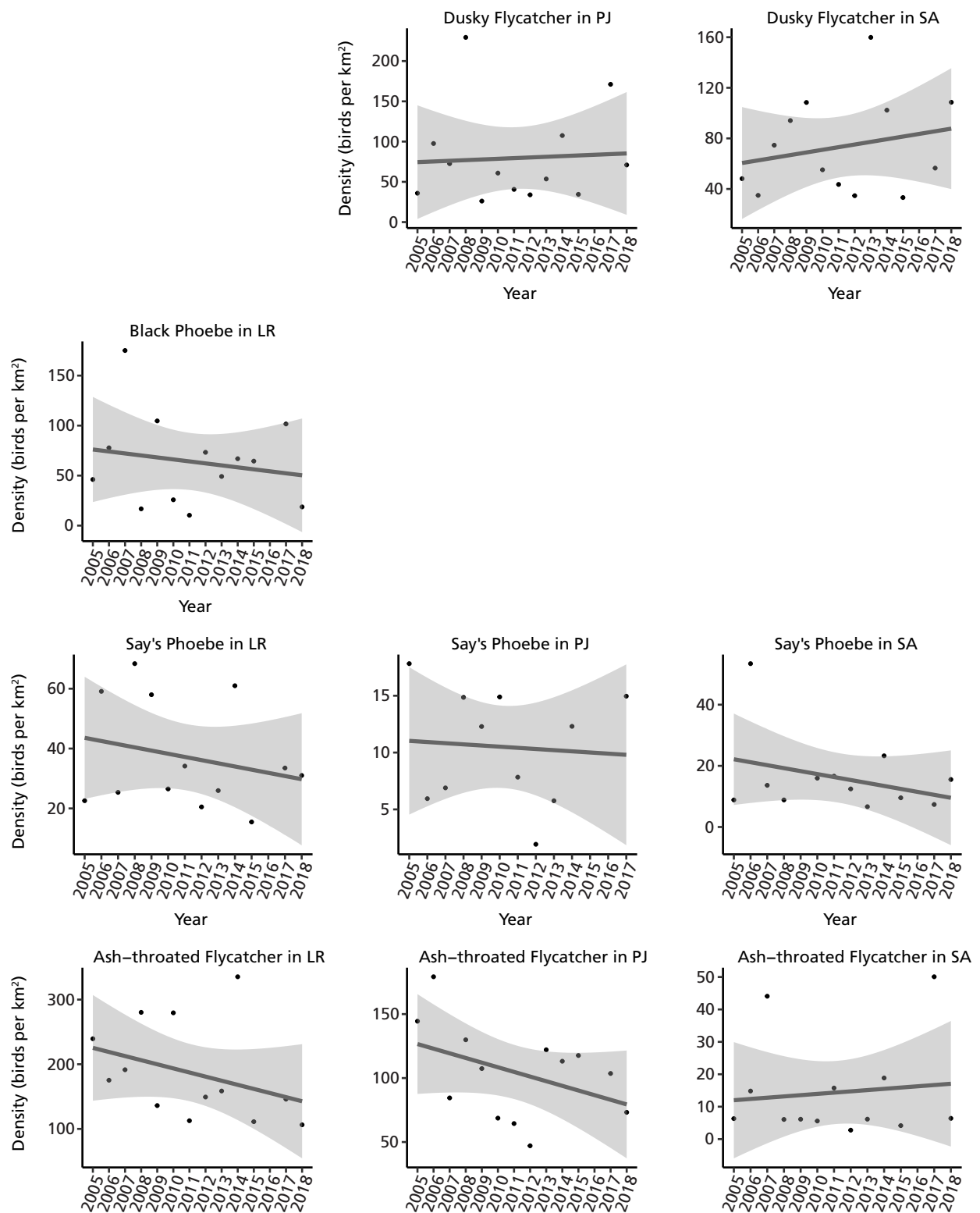
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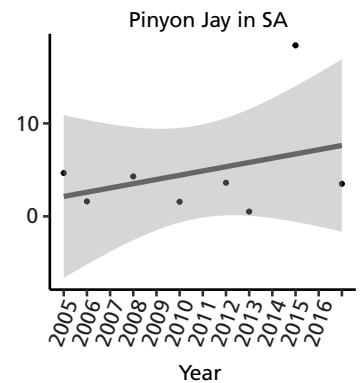
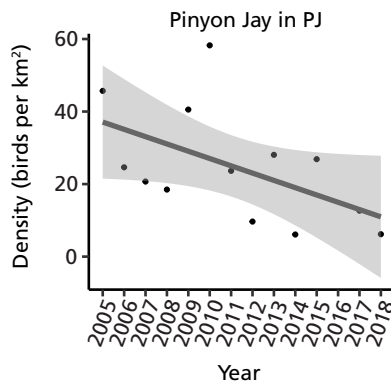
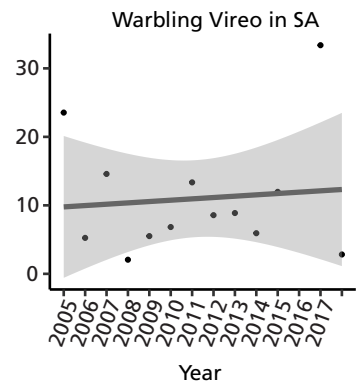
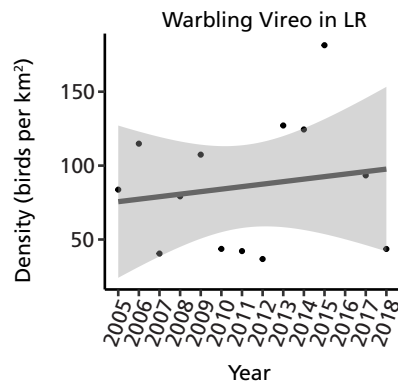
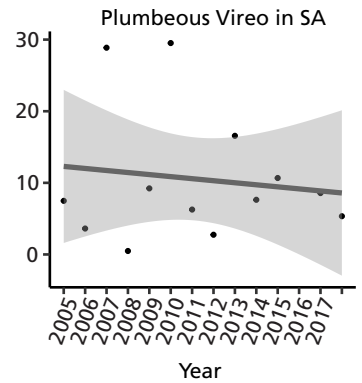
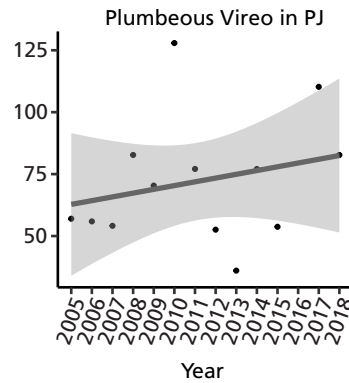
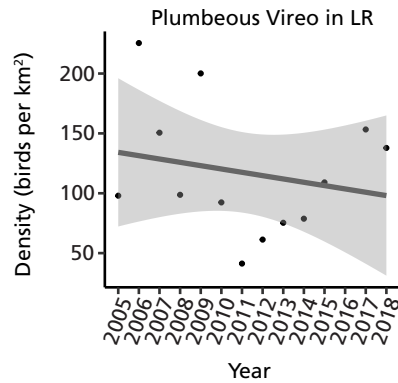
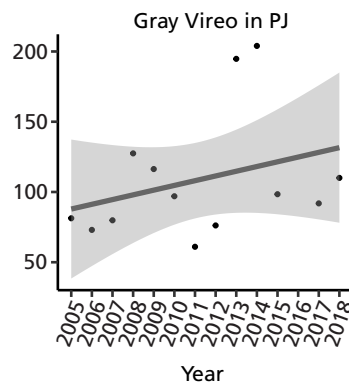
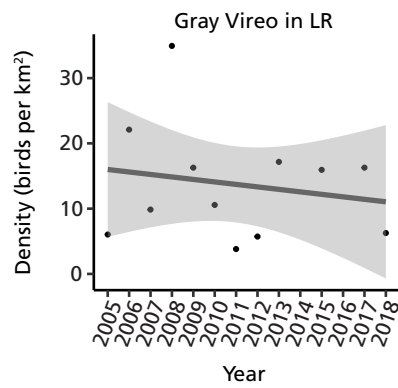
Appendix A. Individual Species Density by Habitat

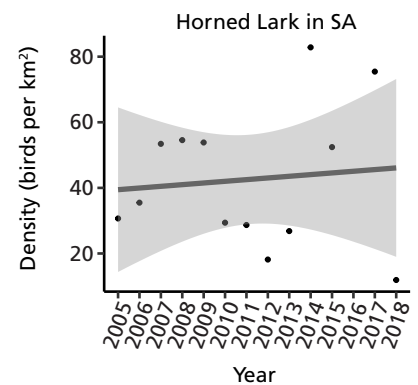
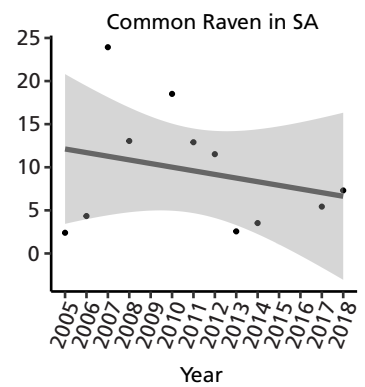
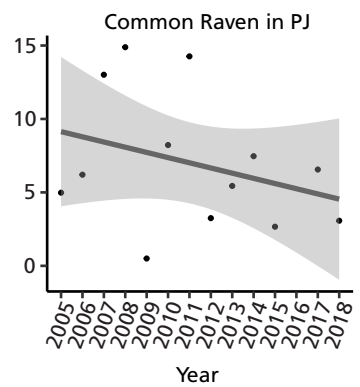
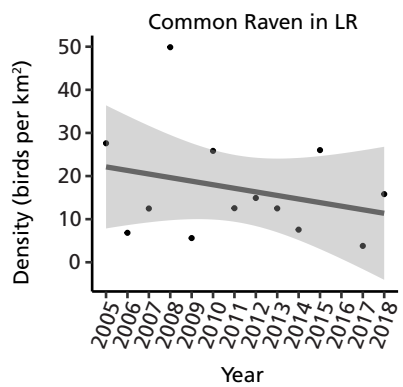
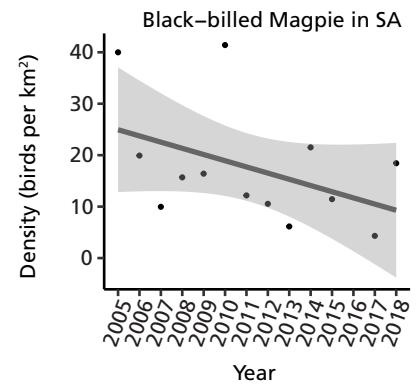
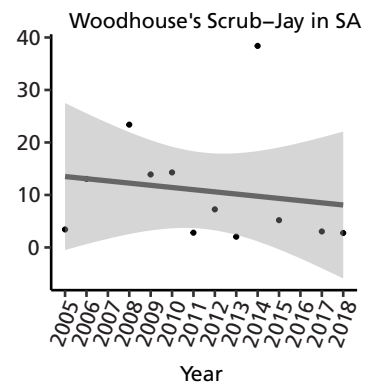
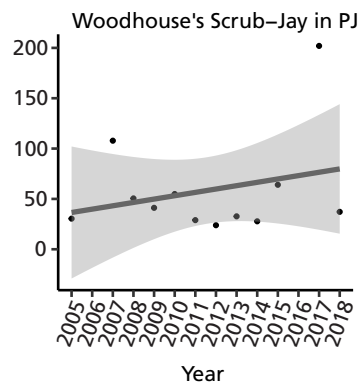
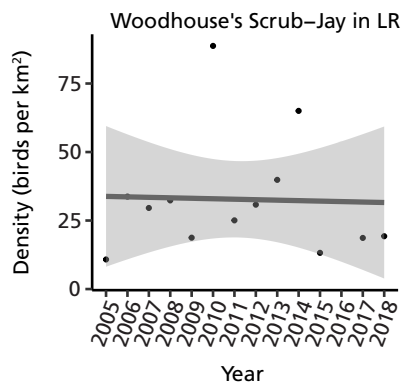
Red lines indicate trends from a simple linear regression model (LR = Low-elevation riparian, PJ = Pinyon-juniper, SA = Sage shrubland).

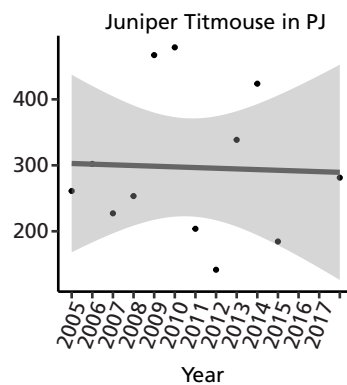
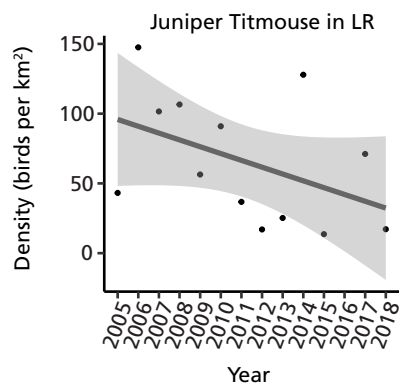
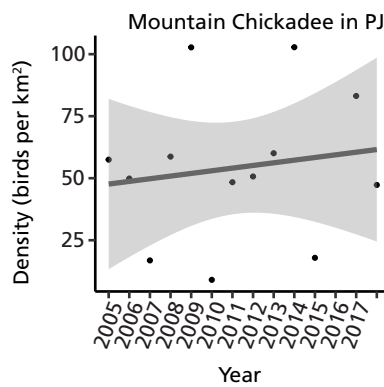
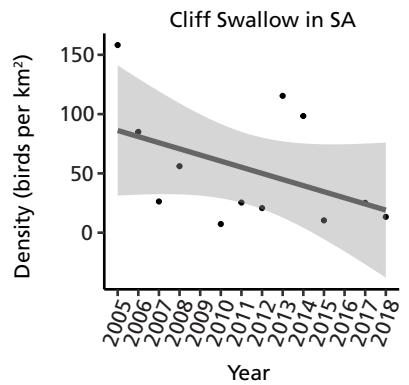
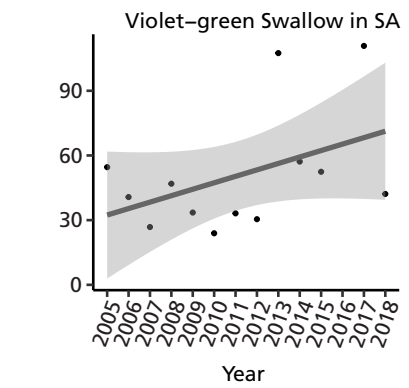
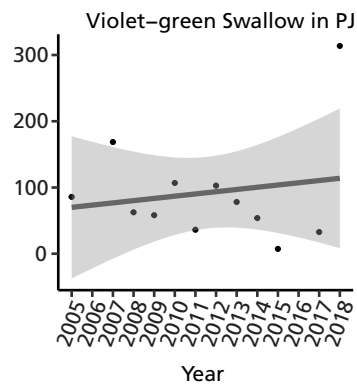


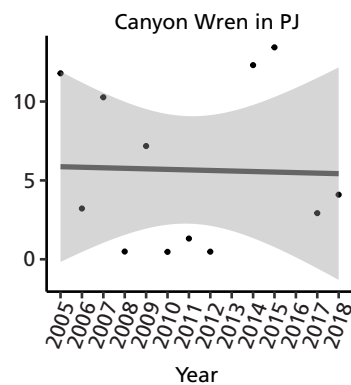
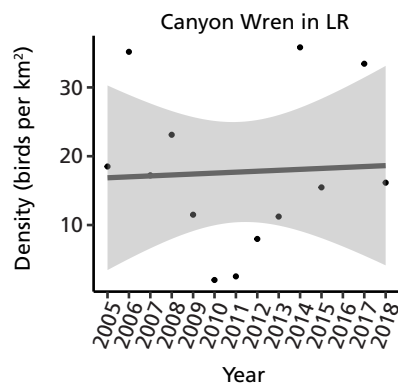
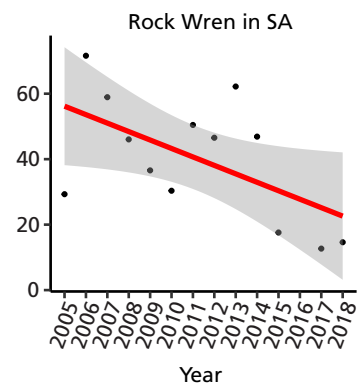
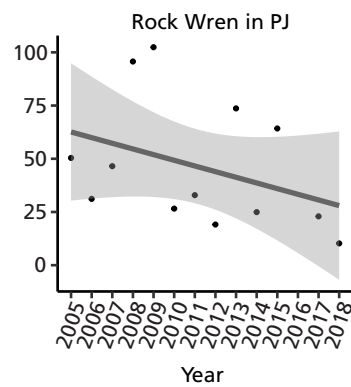
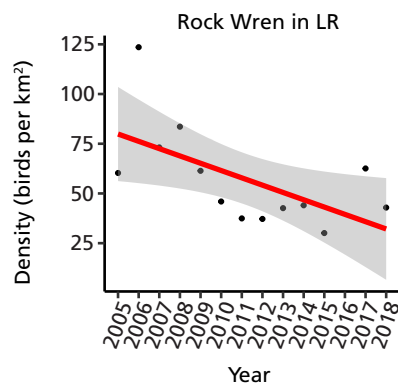
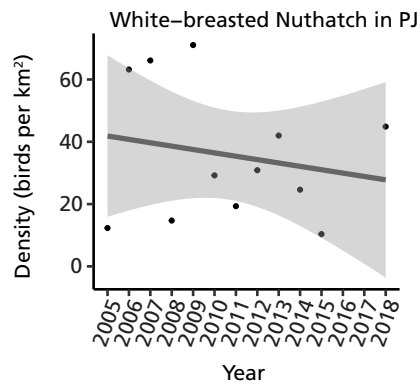
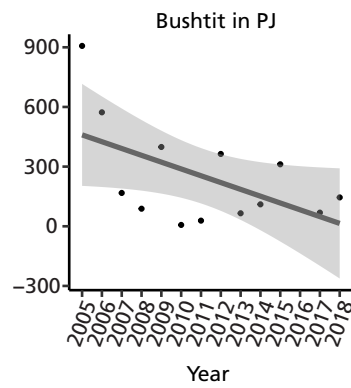
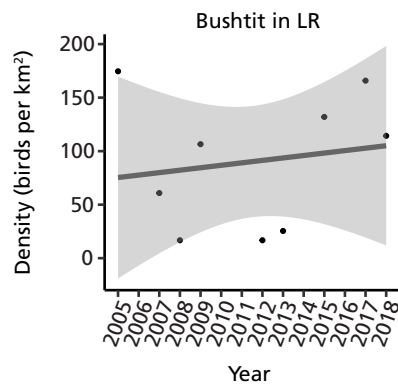


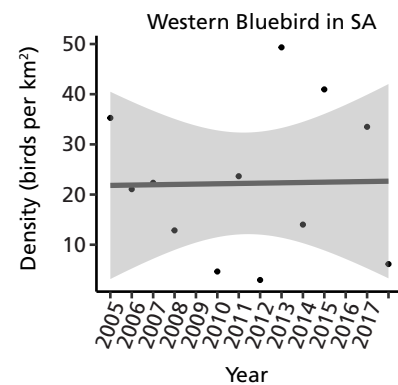
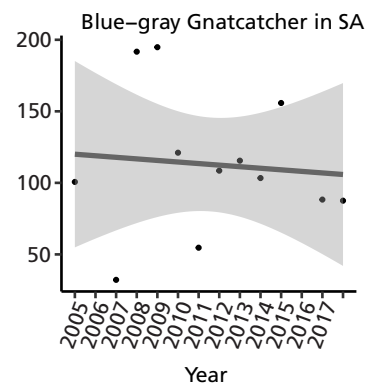
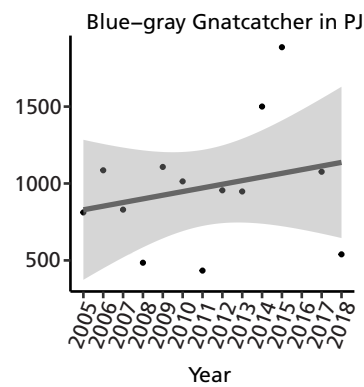
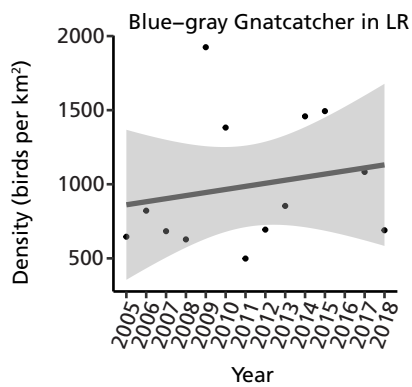
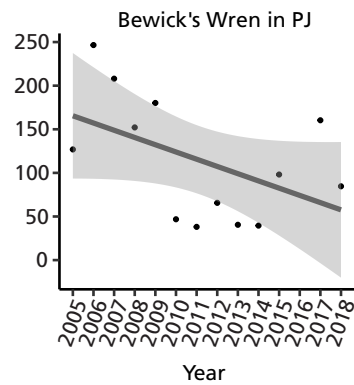
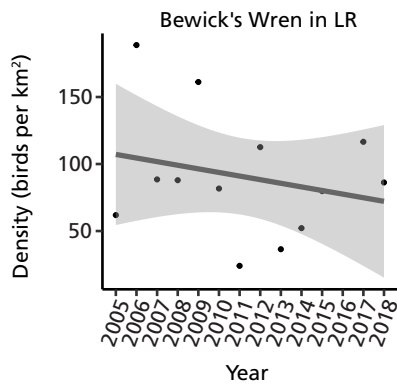
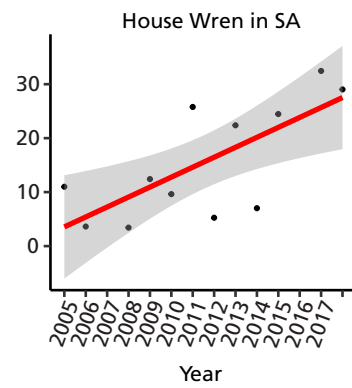
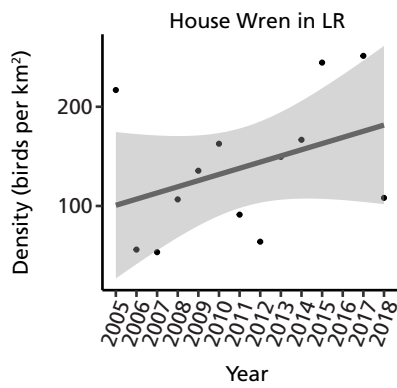


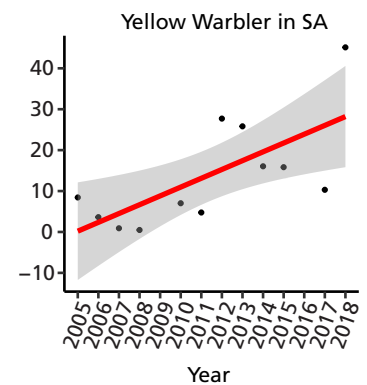
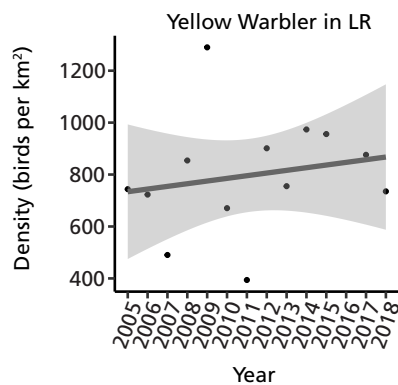
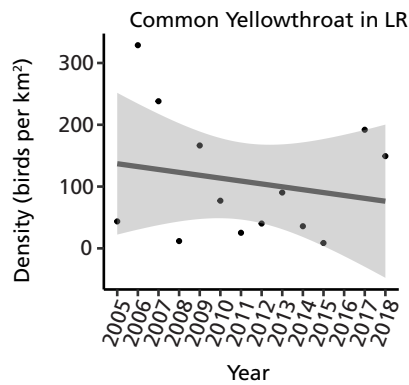
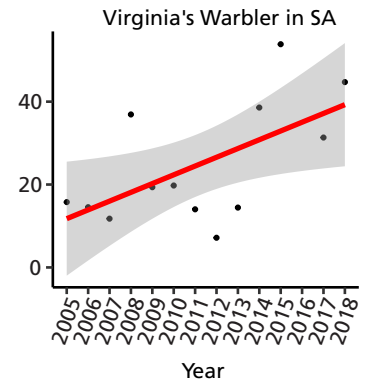
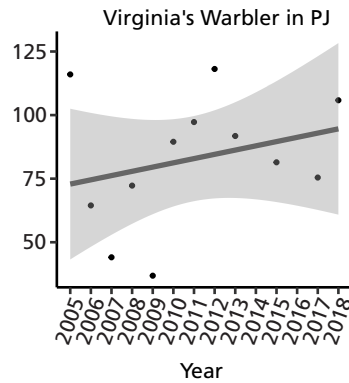
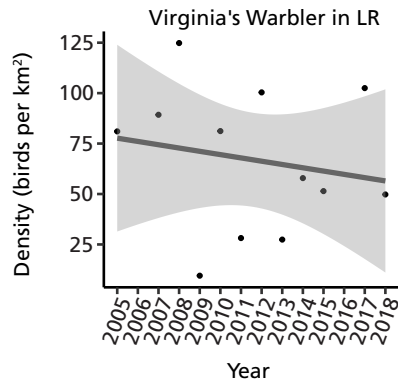
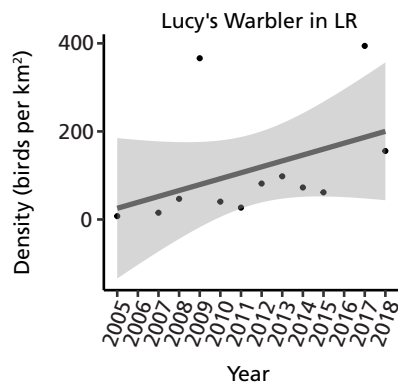


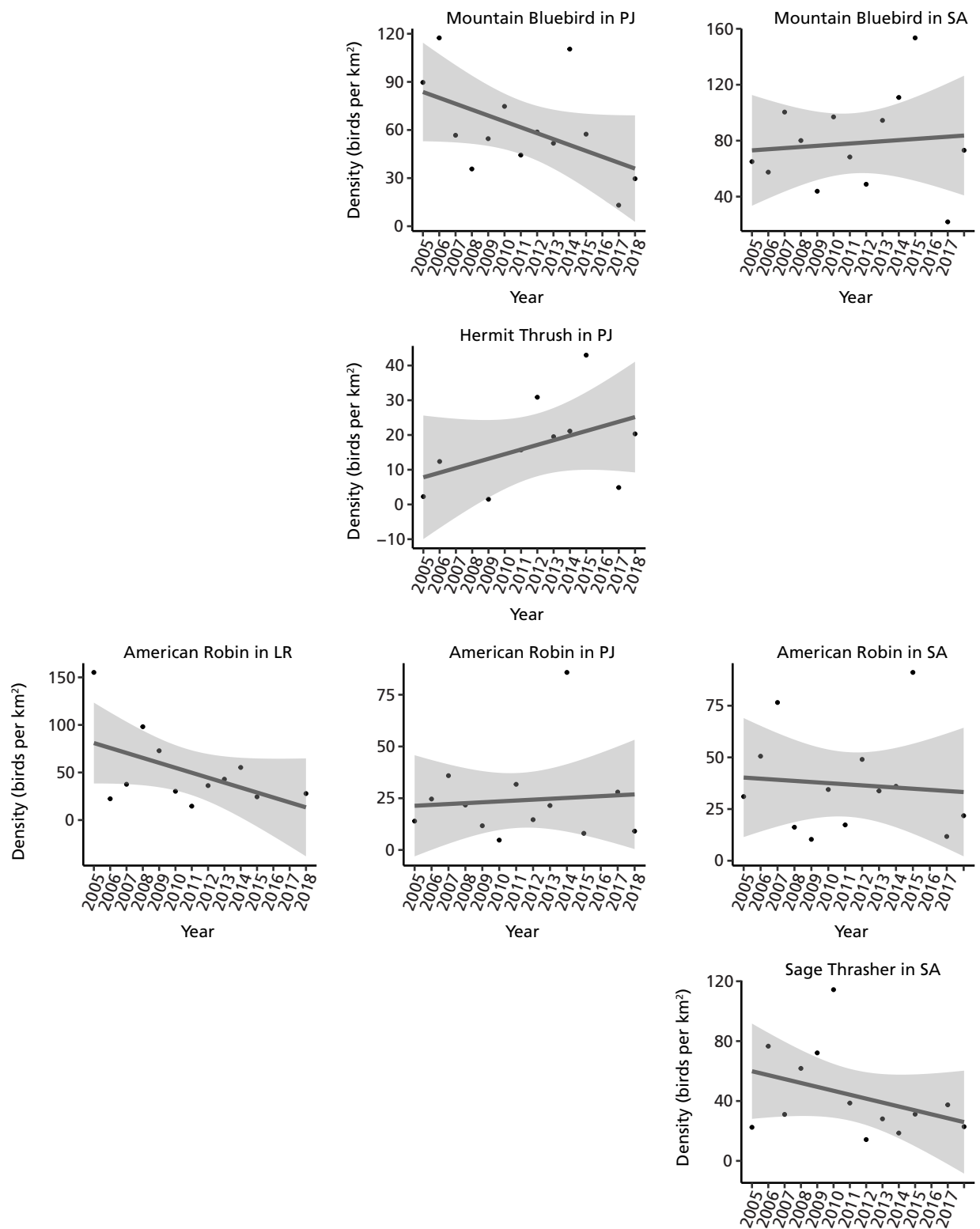


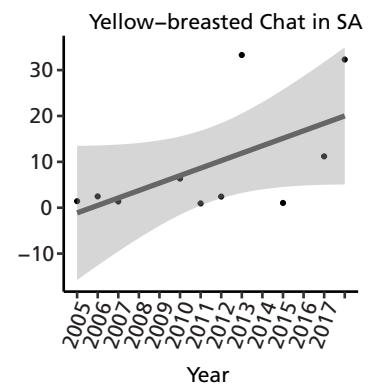
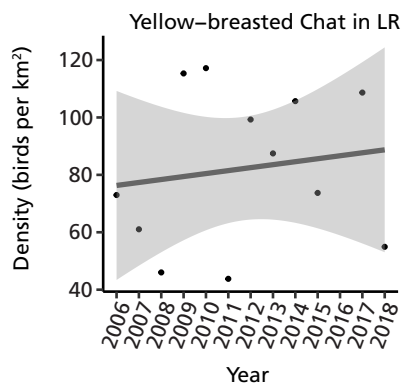
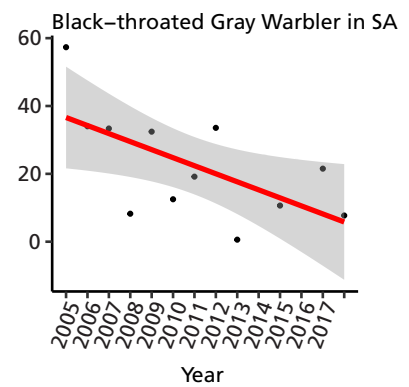
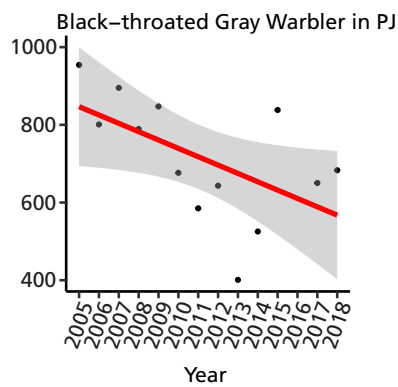
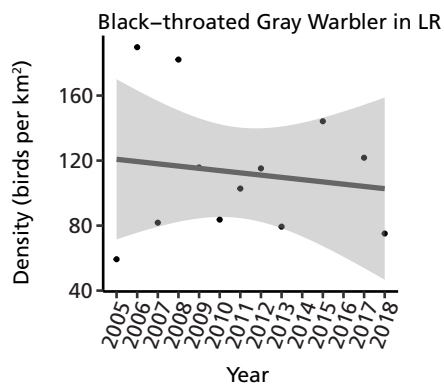
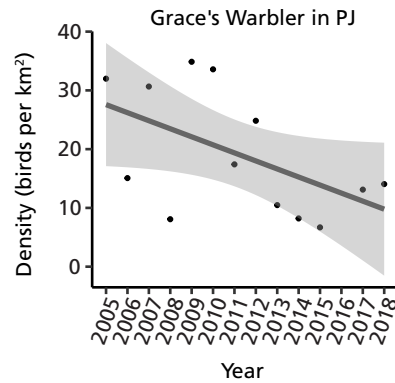
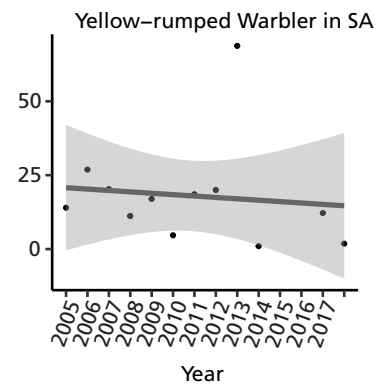
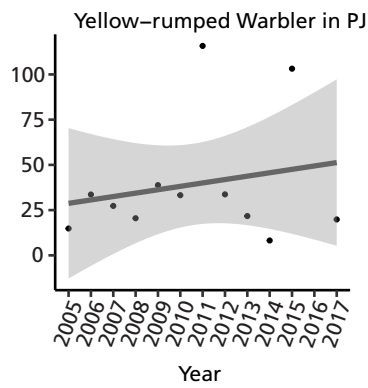
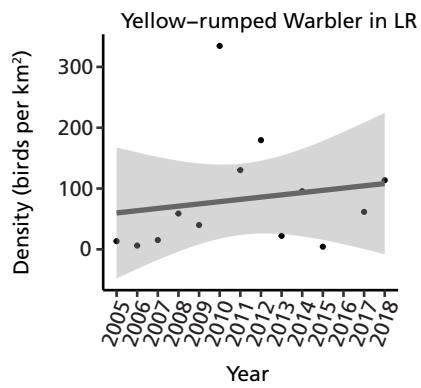


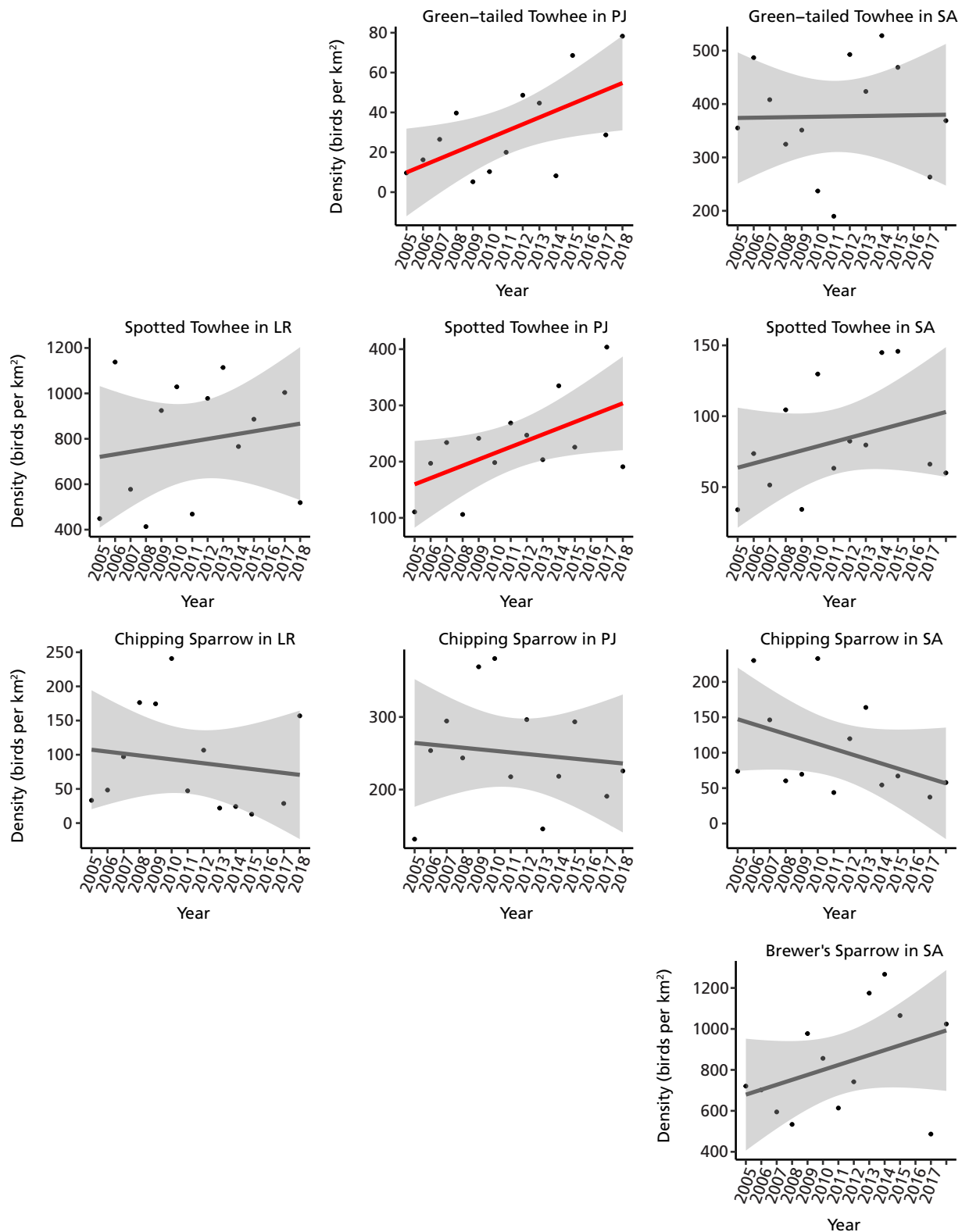


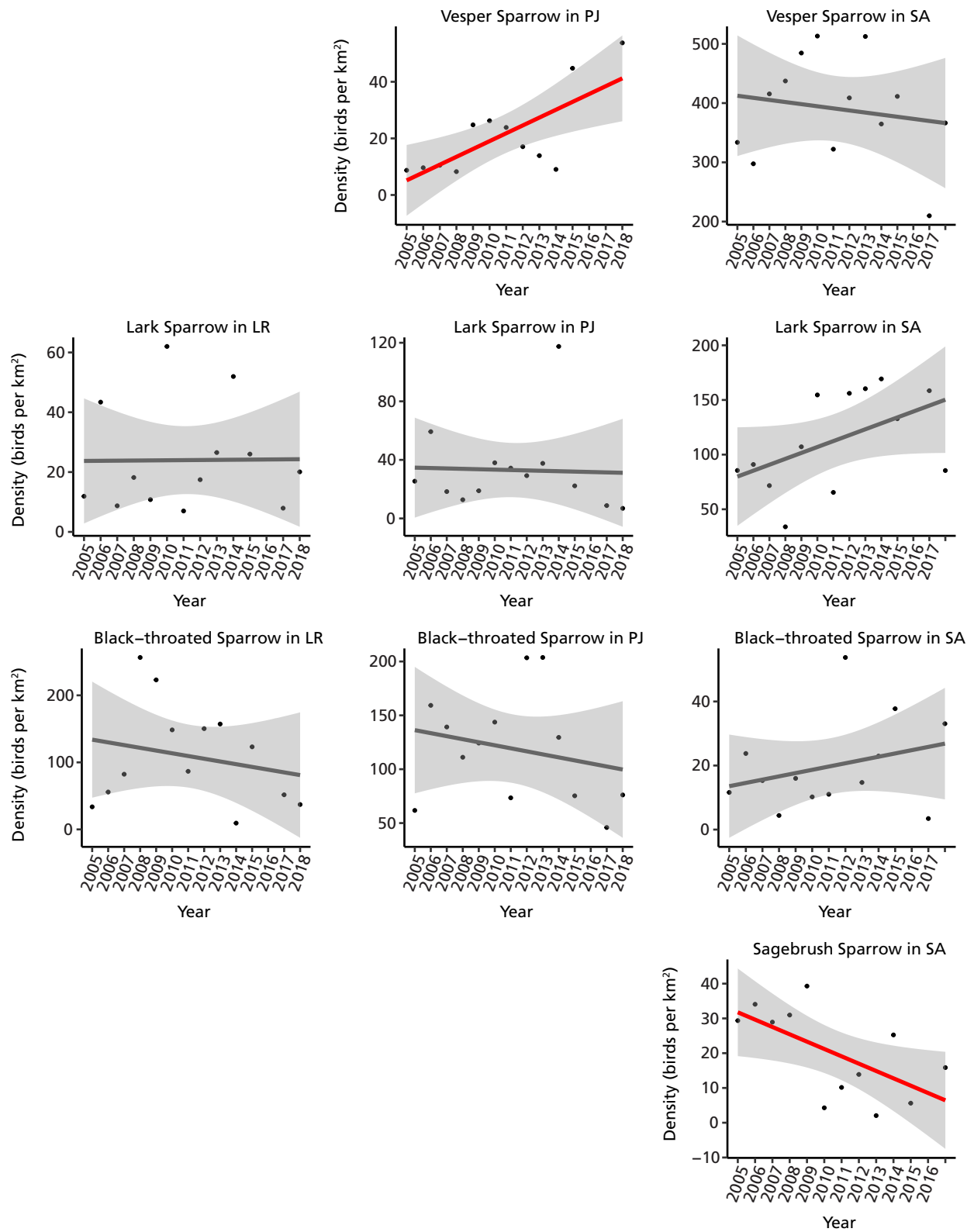


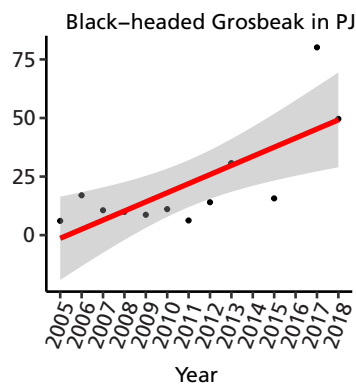
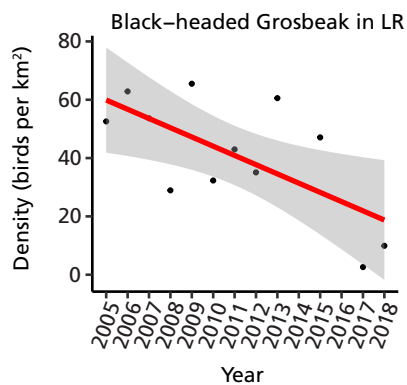
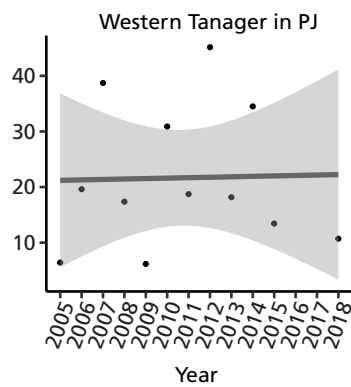
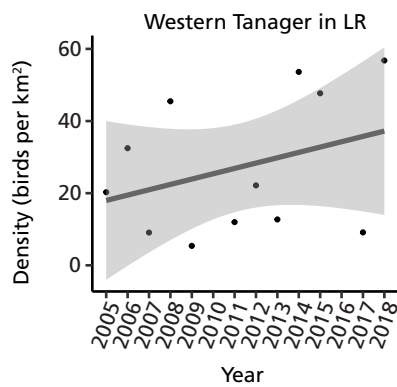
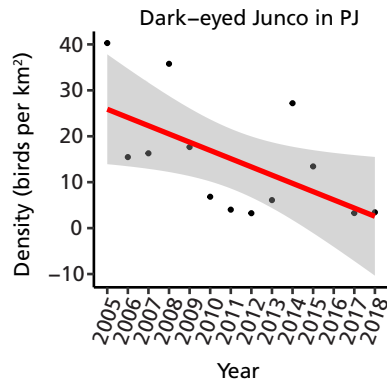
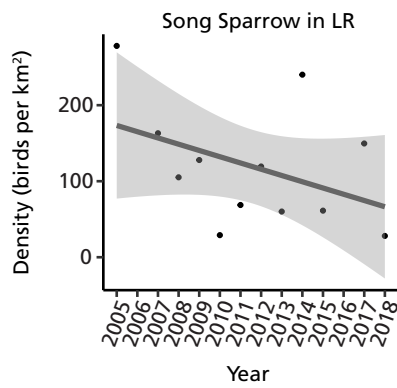


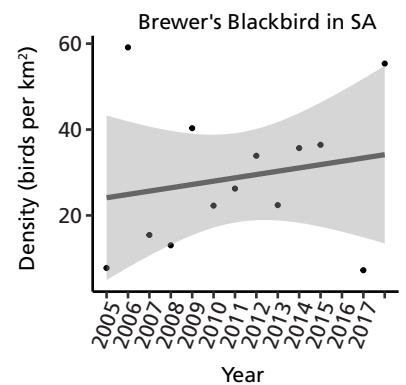
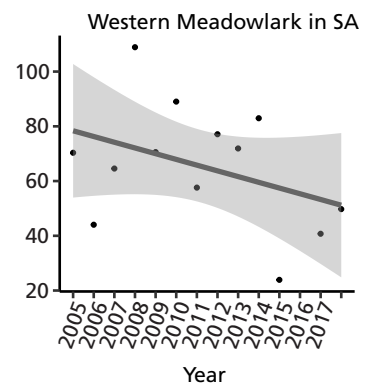
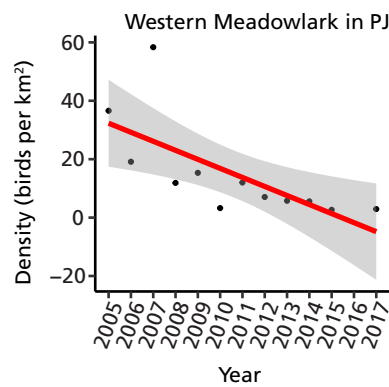
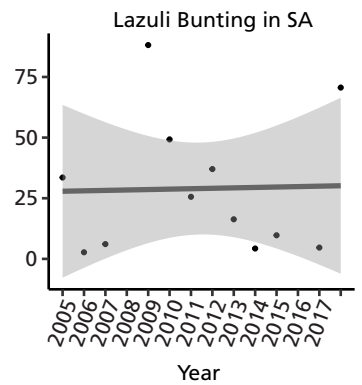
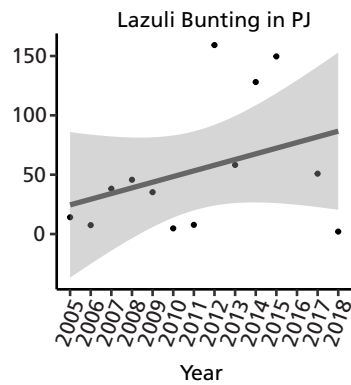
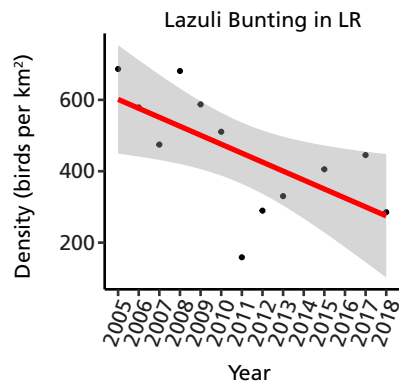
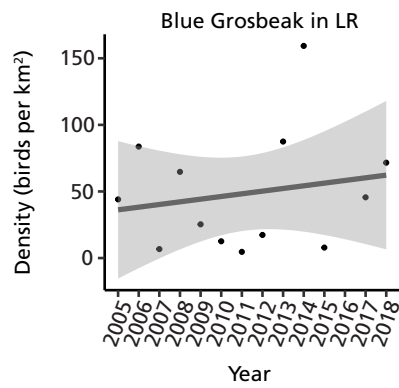


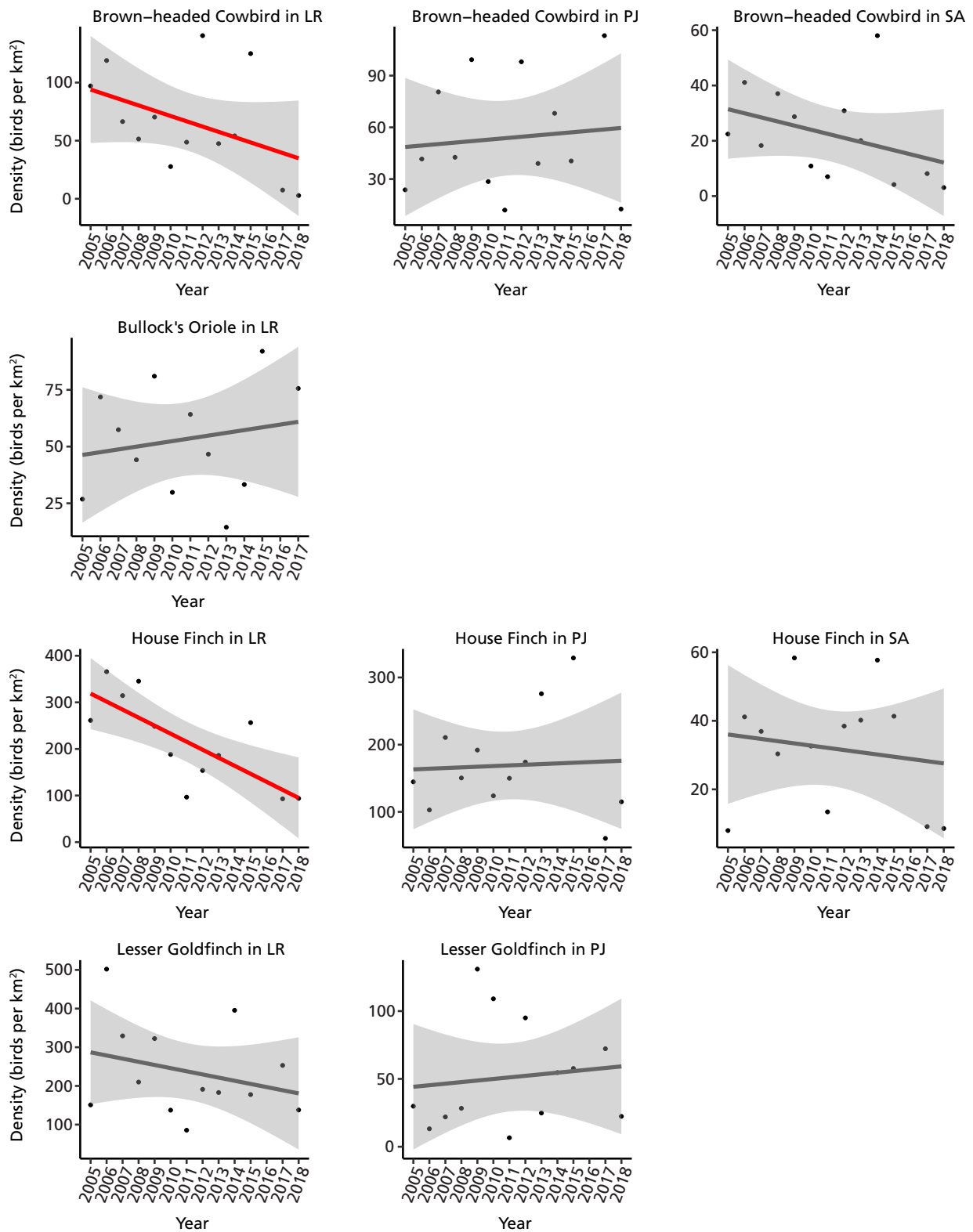












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