SONORAN DESERT BREEDING BIRD MONITORING
2012-2014 SUMMARY REPORT

COORDINATED BIRD MONITORING PROGRAM
ARIZONA GAME AND FISH DEPARTMENT

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EXECUTIVE SUMMARY

Monitoring is a critical element in any conservation effort as it contributes to the decision making processes in an adaptive management context. Arizona encompasses the vast majority of the Sonoran Desert habitat within the U.S. Therefore the Arizona Game and Fish Department has an important stewardship obligation for maintaining viable populations of those species dependent on this habitat. A total of 17 bird species (12%) on Arizona's Species of Greatest Conservation Need (SGCN) list regularly nest in this habitat, however many are not effectively monitored.

This study was implemented to estimate population size, density, and map species distributions of breeding birds in Arizona's Sonoran Desert. Sonoran Desert habitat was stratified based on region, land ownership, and terrain, and delineated over 384,000 survey plots by either 16 or 24 ha in size, corresponding to upper or lower regions of the desert. From 2012 to 2014, 312 randomly selected plots were surveyed. To estimate detection rates, double sampling methodology was used, where all selected plots are surveyed rapidly, and a random subset is surveyed intensively. Intensive surveys were conducted on 28 (9%) of the plots. Vegetation data describing the diversity and structure of vegetation were collected on 310 (99%) plots.

During rapid surveys 15,909 birds of 72 breeding species were recorded. Of the 17 SGCN bird species, estimates of density and population size were obtained for nine based on >30 individuals per species. The remaining seven are very locally distributed, rare, or primarily nocturnal in the Sonoran Desert, and require separate monitoring methods. The total number of birds in the study area is about 30 million with an overall density of 437 birds/km^2. In addition, nest site data was collected at approximately 875 active nests of 38 species.

The evaluation of the intensive method yielded accurate estimates of the detection rates even though the very small sample of intensive surveyors (n=3) in the evaluation test showed considerable variation. The evaluation suggested several ways to improve intensive surveys through more training.

Recommendations for a long-term monitoring strategy include a design where coordinators select new plots for each set of surveys, survey a minimum of 300 plots during three years with a five or six year break between surveys. This study provides baseline population estimates for bird species of the Sonoran Desert and sets the foundation for estimating population trends in the future.

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Coordinated Bird Monitoring Program, Arizona Game and Fish Department

Troy E. Corman, Edwin A. Juarez, John E. Arnett, Jr., Carol J. Beardmore (Eds.)

INTRODUCTION

Arizona's avifauna is particularly diverse due to factors such as geography, proximity to tropical influences, and a variety of ecosystems. The number of native bird species documented in Arizona is close to 550, with nearly 300 breeding at least occasionally in the state (Corman and Wise-Gervais 2005). Many of these have a significant portion of their distribution (seasonal or year-round) in Arizona; therefore the state's land and wildlife management agencies have a responsibility in their conservation.

Nationally, the North American Breeding Bird Survey (BBS) and Christmas Bird Counts (CBC) have indicated downward trends for many species (NABCI 2009). However, many of Arizona's bird species are poorly monitored by the BBS, CBC, and other large-scale surveys including:

- Species that breed in marsh, riparian, and grassland habitats.
- Sonoran Desert species that breed in late winter or early spring before the BBS survey period, or during the late summer monsoon season.
- Colonial nesting species.
- Nocturnal species.

Existing avian monitoring projects are insufficient to detect population trends since they are:

- Local in nature.
- Short or intermittent in duration.
- Not coordinated on a statewide level.
- Have no central repository for data.

Because of these factors, biologically important population trend information is lacking. This information is important to track bird populations which face threats that impact the quantity and quality of their habitats through fragmentation, alteration, or loss (Corman and Wise-Gervais 2005; NABCI 2014). Land and wildlife managing agencies are in need of statewide data to:

- Identify distribution, and estimate population size and trends in order to prioritize species of concern.
- Identify research needed.
- Implement, evaluate or modify conservation actions and plans to stabilize or increase populations to preclude their federal listing under the Endangered Species Act.

To understand the magnitude of threats on bird populations and to help mitigate those threats, a myriad of partners formed the Arizona Bird Conservation Initiative (ABCI) in 1991. Coordinated by the Arizona Game and Fish Department (Department), ABCI is a voluntary partnership of government agencies, conservation groups, academic institutions, private businesses, and

citizens working to conserve, monitor, and enhance bird populations and their habitats with the goal of "keeping common birds common."

In 2006, an ABCI working group conducted a "Monitoring Needs Assessment" to prioritize bird species that are in need of population monitoring and research in Arizona. The group derived assessment scores from the Partners in Flight North American Landbird Conservation Plan (Rich et al. 2004) in conjunction with an analysis of Arizona BBS data. The assessment identified 181 priority species, of which approximately 168 should be monitored during the breeding season. The group adopted a long-term, landscape-scale, multi-species monitoring approach based on this assessment. This approach will:

- Maintain coordination and support for long-term monitoring projects with established protocols (e.g., BBS and CBC);
- Implement or expand monitoring of aquatic species and habitats, particularly colonial nesting waterbirds and marsh birds; and
- Design and implement multi-species monitoring projects addressing terrestrial species and habitats.

To coordinate this approach, interested ABCI partners established the Arizona Coordinated Bird Monitoring (AZCBM) Program under the Department's direction. The AZCBM facilitates the pooling of resources (i.e. more economical) from multiple agencies to ensure AZCBM's long term sustainability. General objectives of the AZCBM include:

- Determine current population status and detect biologically important trends.
- Determine current distribution and detect changes.
- Determine seasonal habitat associations.
- Coordinate short-term monitoring projects to determine the effectiveness of specific management activities.
- Assist in establishing management and conservation priorities.
- Support integration of data into the Avian Knowledge Network.

Guided by the assessment, the ABCI working group initiated work on a monitoring approach for priority species that breed in the Sonoran Desert of Arizona. Migratory birds rely on desert landscapes (including associated wooded washes) for breeding, wintering, and as migration corridors. A total of 17 bird species (12%) on Arizona's Species of Greatest Conservation Need (SGCN) list regularly nest in this unique habitat. Sonoran Desert ecosystems have been altered dramatically during the past 150+ years. Existing changes to this habitat that may affect bird species include extensive urban and rural development, prevailing drought, inappropriate livestock management, off-highway vehicle (OHV) recreation, heavy border activity, and introduction of unnatural wildfires due to invasive exotic vegetation (Latta et al. 1999). Future expansion of alternative energy (solar and wind) projects will add to the threats to this habitat (AGFD 2012).

Implementation of the landscape level monitoring strategy for Sonoran Desert birds required a high level of coordination between land and wildlife management agencies across the region. ABCI brought together numerous partners to accomplish this task including: Department of Defense (DoD), Tohono O'odham Nation, Bureau of Land Management (BLM), U.S. Fish and Wildlife Service including Sonoran Joint Venture, Tonto National Forest, National Park Service,

Audubon Society and other collaborators. This coordination helped facilitate the study design (landscape level), pooling of resources, logistical assistance, and over-all support for the monitoring strategy.

The specific objectives of the Sonoran Desert Breeding Bird Monitoring study are to estimate the population abundance, density, size, trends (once surveys are repeated), and spatial distribution of birds that breed in the Sonoran Desert of Arizona. For the Department, this study fills a critical information need for "Unknown Status species". Unknown status species are those SGCN species that Scored "0" for Vulnerability in one of eight assessment categories. Meaning there are no data with which to address one or more categories, and vulnerability status cannot be assessed. Therefore "unknown status species" represent priority research and information needs for the Department.

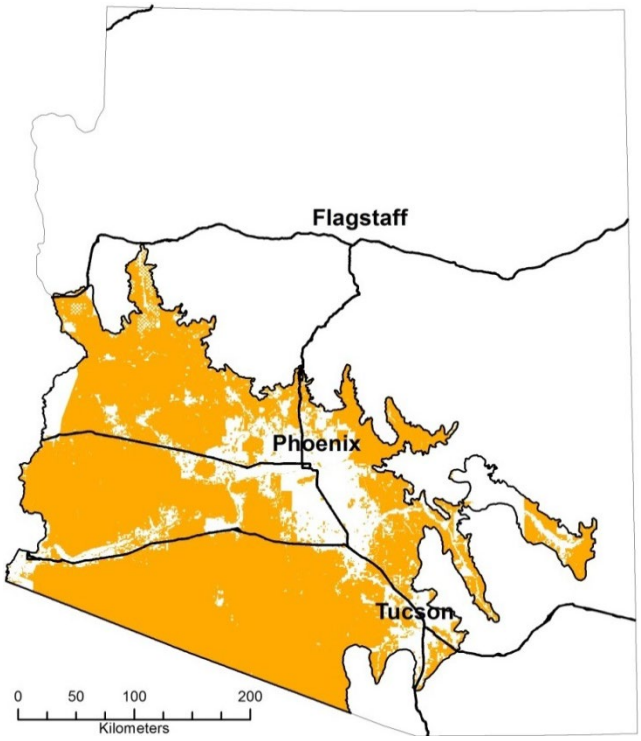
This report consists of two Chapters authored by Dr. Jonathan Bart, U.S. Geological Survey (retired). Chapter 1 describes the overall study design, sampling plan, results, and conclusions of the bird surveys. Chapter 2 is an in-depth analysis of the double-sampling method used during this study.

CHAPTER 1: SONORAN DESERT BIRD SURVEY AND ANALYSIS

Jonathan Bart, Jon Bart Consulting

STUDY AREA AND DESIGN

The study area (Figure 1.1) was located within the Sonoran Desert region of Arizona, as defined by Omernik's Level III Ecoregions (Omernik 1987). Private lands and tribal areas (except the Tohono O'odham Nation) were excluded.

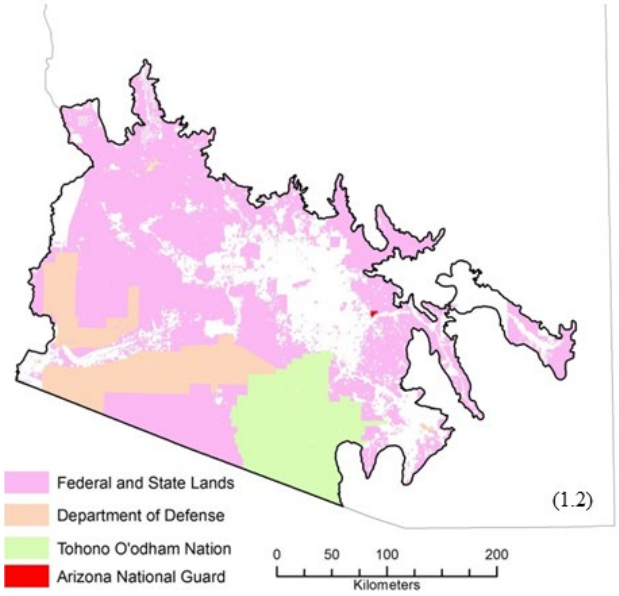


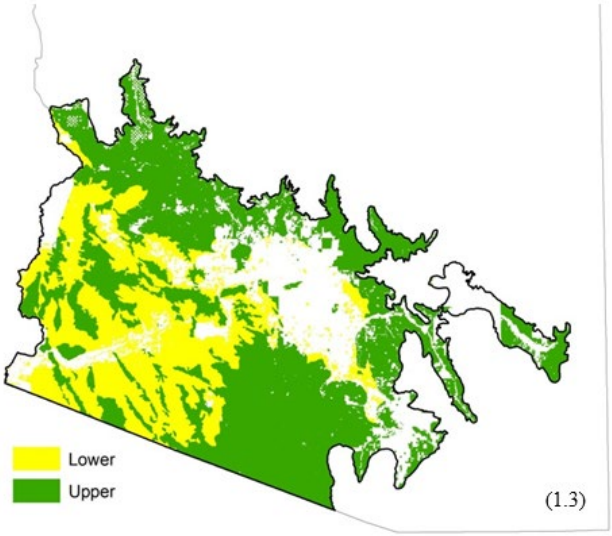
Strata were delineated using ownership, "region", and "ruggedness." The four ownership categories were Federal and State Lands, DoD, Tohono O'odham Nation, and Arizona National Guard (Figure 1.2). Expecting more birds at higher elevation where vegetation density and diversity is typically greater (Latta et al. 1999), strata were sub-divided using Omernik (1987) level IV categories into Upper Sonoran Desert (i.e., above 450 m) and Lower Sonoran Desert (i.e., below 450 m) (Figure 1.3).

Figure 1.1. Study area (orange) within the Sonoran Desert in Arizona, (Ecoregion 81 as defined by Omernik [1987]).

Figure 1.2. Broad scale land ownership within the study area.

Figure 1.3. Upper and Lower Sonoran Desert regions in Arizona based on Omernik's level IV eco regions (Omernik 1987).





Based on studies using similar methods to the bird and vegetation densities expected in the Upper Sonoran Desert (Bart et al. 2012, 2018 in prep.), a 16 ha plot was initially determined to be a suitable monitoring size. However, a pilot study in 2011 showed a larger plot was necessary in the Lower Sonoran Desert due to lower bird and vegetation densities (Arnett pers. comm.). Thus, the study area was partitioned into 16 ha plots in the Upper Sonoran Desert, and into 24 ha plots in the Lower Sonoran Desert (Figure 1.4).

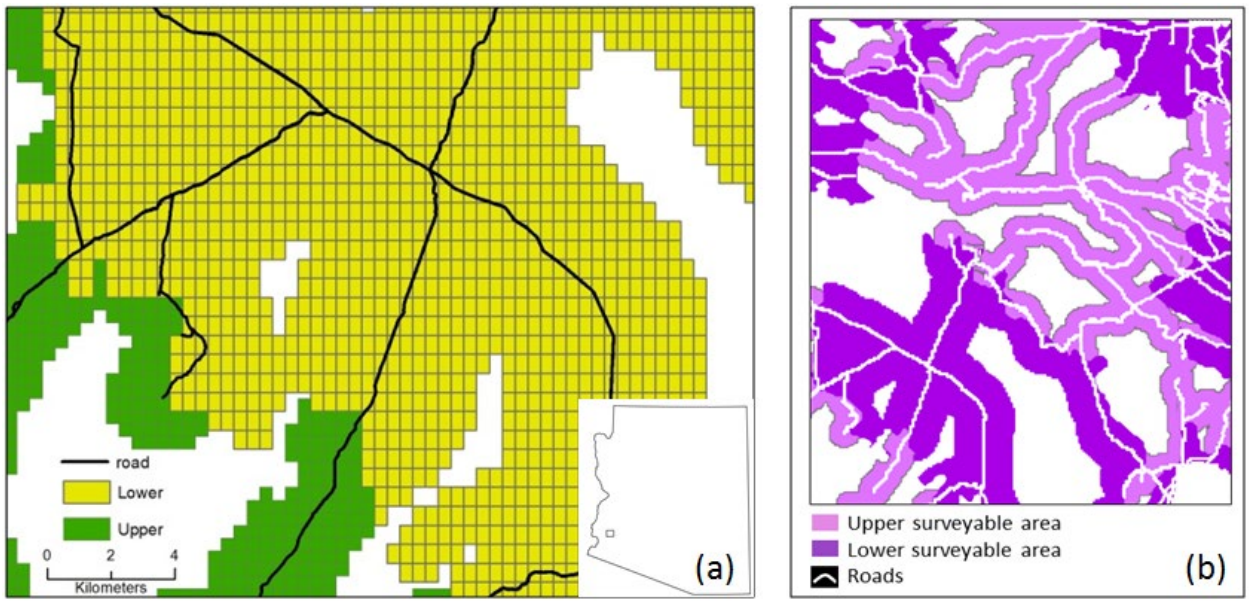


Figure 1.4. (a) Section of study area depicting how plots partitioned in Upper and lower Sonoran Desert. (b) Section of study area depicting how the potential survey areas were established within a set distance from roads. Plot centroids could be no more than 1.5 km from the nearest road in the Upper Sonoran Desert and no more than 3 km from the nearest road in the lower region.

Other factors also affected plot locations. Some portions of the study area were too distant from the nearest road to be logistically feasible to survey. In addition, due to higher vegetation density and uneven, rocky terrain, it was anticipated that hiking and surveying in the Upper Sonoran Desert would be more difficult than the Lower Sonoran Desert. Also, to reduce noise effects from vehicular traffic a 250 m buffer was applied around paved roads. Thus, plot centroids were established no more than 1.5 km from the nearest paved road in the Upper Sonoran Desert and no more than three km from the nearest road in the Lower Sonoran Desert (Figure. 1.4). Inaccessible DoD lands (i.e., active training ranges, and other areas) were excluded. Biologists familiar with the inaccessible areas (Figure 1.5) determined they were similar to adjacent accessible areas, and a statistical extrapolation could be made.

Plots (or sections of plots) in, adjacent to, or partially located in mountainous areas were often difficult or impossible to safely survey as they contained excessively steep slopes. In 2013, those areas were identified using the Sappington et al. (2007) ruggedness index, and the amount of "rugged" area was calculated in each plot. Defining those as "edge plots", a select sample were included based on a proportion of survey area. If plots did not meet the minimum survey area (≥12 ha), they were excluded from the sample.

The study area covered 69,193 km^2 and was delineated into 384,512 plots across 11 strata which were defined using ownership, region, and ruggedness (terrain) (Table 1.1).

Table 1.1. Descriptions of the 11 strata by ownership, region, and terrain.

Stratum	Land Ownership	Region	Terrain	Plots	Area (km^2)	Surveyed Plots
1	Federal and State lands	Upper	Normal	158,919	25,647	112
2	Federal and State lands	Upper	Rugged edge	43,663	7057	22
3	Federal and State lands	Lower	Normal	60,955	14,262	74
4	Federal and State lands	Lower	Rugged edge	4393	1044	3
5	Tohono O'odham Nation	Upper	Normal	65,852	10,589	15
6	Department of Defense	Upper	Normal	12,367	1986	13
7	Department of Defense	Upper	Rugged edge	6567	1062	4
8	Department of Defense	Lower	Normal	29,709	7055	61
9	Department of Defense	Lower	Rugged edge	1966	469	3
10	Arizona National Guard	Upper	Normal	60	10	3
11	Arizona National Guard	Lower	Normal	61	12	2
Total				384,512	69,193	312

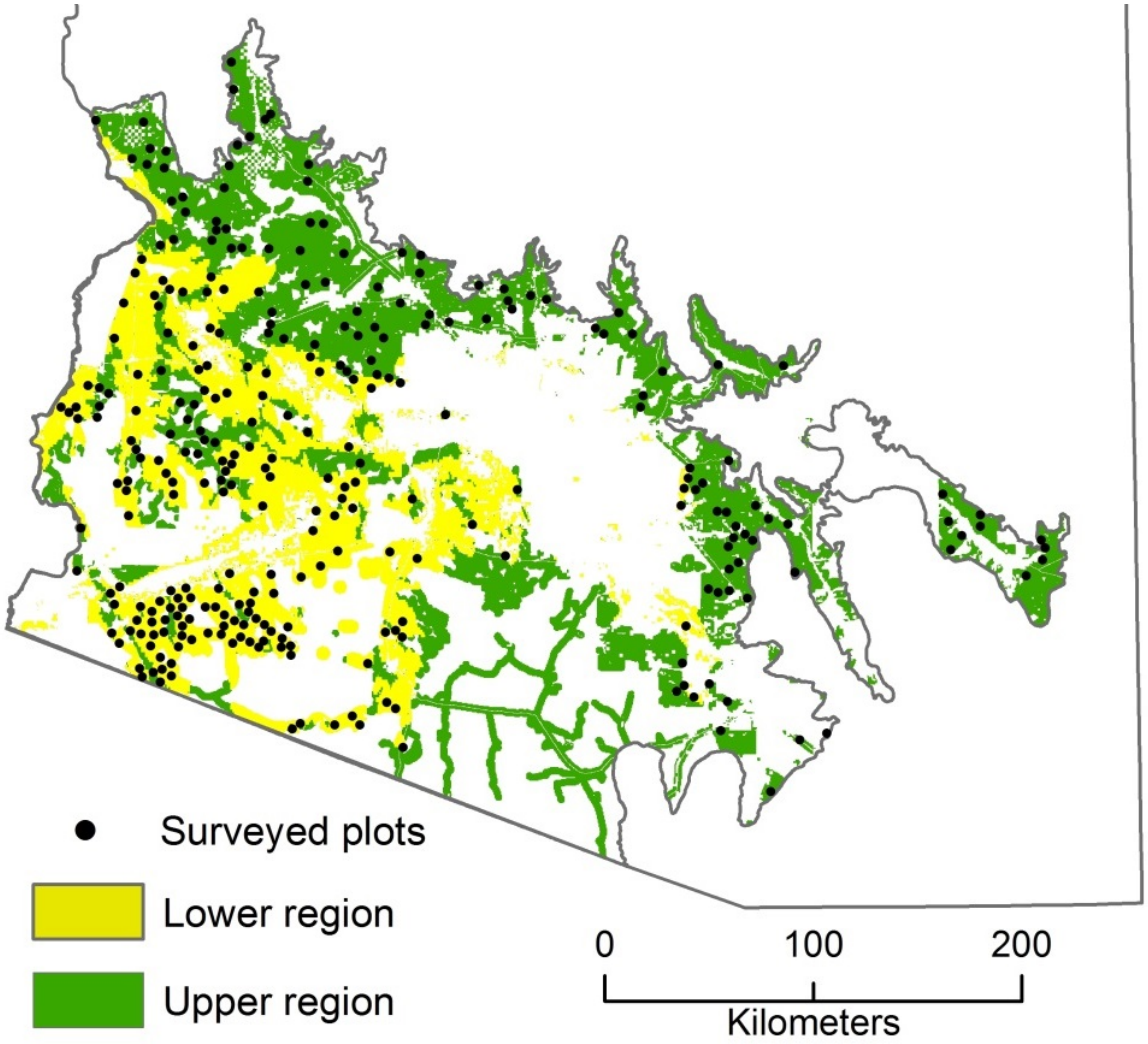


Figure 1.5. Surveyed plots within accessible portions of the study area (compare to Figure 1.3).

Simple random sampling was used to select plots within each stratum. Using a double sampling approach, a large sample of plots was surveyed using a rapid survey method ("rapid plots") and a subset of those using an intensive survey method ("intensive plots")—see Rapid and Intensive Surveys. The ratio of the number recorded (with rapid surveys) to the number actually present (as determined with intensive surveys) provides a "detection rate" that is used to adjust results from the initial large sample of plots (Cochran 1977). Plots were surveyed in one of three consecutive breeding seasons (2012-2014).

To estimate breeding bird population size by species throughout the study area, a rule set was established for defining the number of birds "in" each plot so the population size equals the sum of the birds in all plots. The rule set classified birds by whether they bred within the study area, had well-defined territories, and/or constructed a nest (Table 1.2). For example, for species that breed within the study area and have well-defined territories, the number of birds in a given plot equals the number of birds whose first nest built during the intensive survey period was in the plot plus the number of birds that did not build a nest (e.g., because they did not attract a mate) but whose centroid of singing perches (males) or locations (females) was within the plot. Although this rule set is somewhat complex, it provides the best way to rigorously estimate population size. Incidental observations were not used in estimating density or population size.

Table 1.2. Rules for determining the number of birds in a plot.

Breeds within the study area?	Has a well-defined territory?	Constructs a nest?	Number of birds in the plot
Yes	Yes	Yes	Number whose first nest, active during the intensive survey period, is within the plot
Yes	Yes	No	Number whose centroid of singing perches (males) or locations (females) is within the plot during the intensive survey period.
Yes	No	-	Mean number present during the intensive survey period
No	-	-	Always zero

METHODS

Bird Surveys

Bird surveys were conducted using an area survey protocol (Corman et al. 2015, Appendix A). Surveyors documented territories on field plot maps, and attempted to find the first season's nest for each pair. Because most species have territories smaller than a few hectares, many territories were wholly within a plot. Surveyors did not attempt to find nests for such species, unless the species occurred in such high densities that finding nests was the most accurate method to count the number of birds present. However at the edge of the plot the surveyor searched for the location of the active nest to determine if the bird was breeding within the plot. Surveyor's notes recorded bird detections and nests locations, and stages of the reproductive attempt. At the end of the season, surveyors made their best judgment about the number of birds of each species in the plot using the rules established.

Rapid Surveys - The majority of Sonoran Desert bird species attempt their first breeding activity during late winter and spring. Therefore, all plots were surveyed using a rapid survey method (i.e., two visits) during February through May. Plots in southern Pinal County (south of Gila

River) and Pima County (from Tohono O'odham Nation east) were surveyed a third time between 15 July and 15 August when the monsoon season triggers the breeding activity of Purple Martin (*Progne subis*), Rufous-winged Sparrow (*Peucaea carpalis*) and Varied Bunting (*Passerina versicolor*). On the third visit, only new pairs and new breeding species were recorded.

Surveys began 30 minutes before sunrise and lasted 3.5 to 4.5 hours in order for surveyors to monitor the entire plot. Surveyors assigned birds they detected to zones as either "desert" or "wash" habitats, and designated them as "breeding" or "incidentals" if they thought the birds were migrants or breeding outside the plot. Surveyors assigned birds to zones based on where they first detected the bird, but assigned a different zone if further investigation revealed a more accurate location. For example, if a surveyor first observed a bird in the plot, and then the bird moved and remained outside the plot, the surveyor might record the bird as an incidental. Surveyors plotted detections on maps as: occupied nest (confirmed breeding), probable nest (probable breeding), pair, male, female, unknown sex, and group (Figure 1.6). Surveyors did not record any fledglings or juveniles observed on a plot.

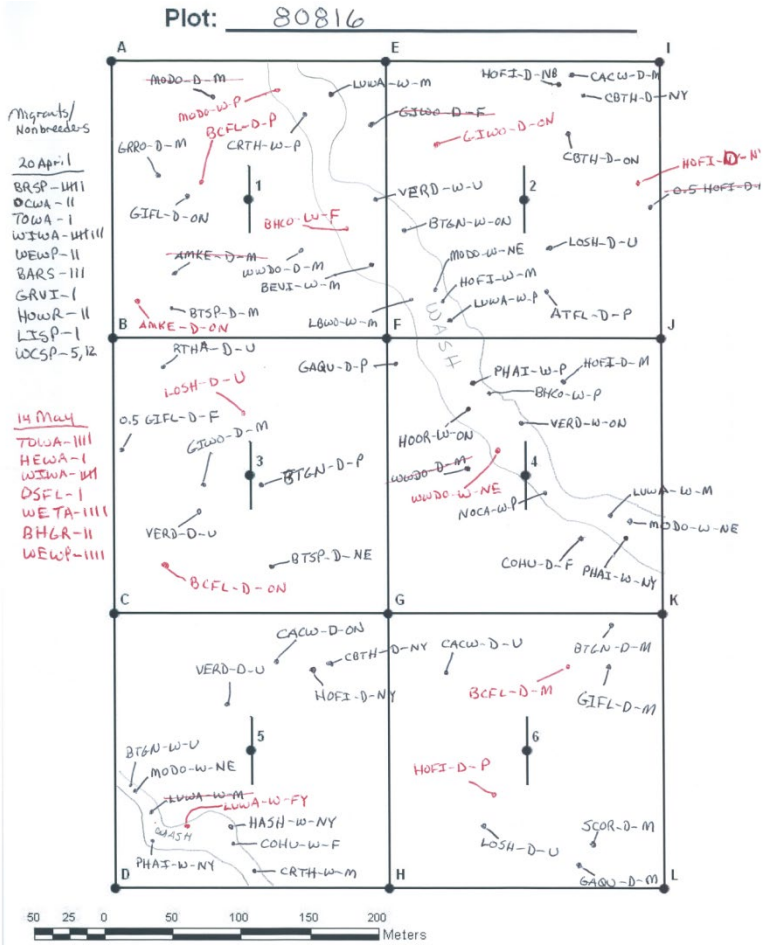


Figure 1.6. Sample plot map showing how detections were recorded during surveys. Red notations are from the second visit.

After each visit, surveyors completed a Visit Summary Form (Appendix A). At the end of the last survey, surveyors summarized the data from all visits and estimated the number of birds of each species in the plot. Surveyors used the survey maps to determine whether multiple detections made during all surveys were of the same bird(s) (e.g., if the surveyor recorded them within the same location). Surveyors recorded the most conclusive evidence for breeding for each individual (e.g., if they saw a pair on one visit and they found its nest on a later visit, then they checked "Occupied Nest" for the pair). For individuals and pairs detected within, but near the edge of the plot, surveyors delineated the territory and recorded 0.5 birds if they determined 25-75% of the territory to be within the plot.

Intensive Surveys – Intensive surveys were conducted on a subset of rapid survey plots to accurately determine the number and the species of breeding individuals within the plot.

Intensive surveys were conducted similar to rapid surveys, but included more visits (i.e., 6-12 times in the Lower Sonoran Desert and 8-16 times in the Upper Sonoran Desert). Visits were distributed throughout the entire breeding season to increase the likelihood of detecting all breeding birds. Different surveyors were used for rapid and intensive surveys on the same plot. Each surveyor conducted a blind survey on the plot but had to coordinate the dates of the visits to avoid surveying the plot on the same day.

LeConte's Thrasher Call-broadcast Surveys

LeConte's Thrasher's distribution and population trends are poorly understood since few (<5) BBS routes occur within their range; they inhabit areas at low densities, and are most detectable in months before the BBS survey period. A study comparing multiple survey periods showed that LeConte's Thrasher detections doubled (January-February) or quadrupled (April-May) relative to detections during the official BBS survey period (J. Arnett, unpublished data). To investigate whether a call-broadcast technique would augment thrasher detections in our study, surveyors in 2012 were asked to use a six-minute call-broadcast survey at six points in each Lower Sonoran Desert plot after completing the area survey. The results showed area surveys were effective at detecting thrashers and call-broadcast surveys did not significantly augment detections.

Habitat Assessment

For each plot, four (on 16 hectare plots) or six (on 24 hectare plots) equally distributed point locations were used to conduct the Point-Center Quarter method (Cottam and Curtis 1956) to estimate the diversity and density of woody plants and cholla cacti (*Cylindropuntia spp*). Mistletoe (*Phoradendron spp*) density, saguaro (*Carnegeia gigantea*) density, and grass/forbs ground cover was also estimated (Corman et al. 2015, Appendix A). Human disturbance and invasive plants were also noted.

Bird Analyses

The data was calculated to provide the best estimate of the number of birds breeding in the plot. For monogamous species, each detection of an active nest, probable nest, pair, male, female, and bird of unknown sex, was assumed to represent a pair. The observations were summed and multiplied by two. For example, if one nest, two probable nests, three pairs, two males, and one female were recorded on a plot, then the total number of observations was nine pairs, and the estimated number of individual birds was 18. The total also included individuals entered as a "group," but were not multiplied as it included unpaired birds.

Estimated population totals or densities for polygynous (e.g., cowbirds [*Molothrus spp*]), and species that do not form pair bonds (e.g., hummingbirds) are not included as it was not possible to devise a rule that consistently gave an unbiased estimate of the number of birds present. However, the excluded species are included in the estimated densities and totals for all species, and in estimates of species richness.

Standard methods for double sampling (Cochran 1977) were used with minor modifications (Bart et al. 2012). For each species the detection rate was estimated using the ratio of the mean number recorded during the rapid survey to the mean number actually present on the plot (as determined in the intensive survey). The mean number recorded on all rapid plots was divided by

the detection rate to provide an estimate of actual numbers present. Standard errors (SE) from variation in the detection rate among intensive plots and variation in numbers recorded on all rapid plots were derived. Calculations were completed by a modified double sampling (DS) program (Bart and Hartley 2011), however certain details of the analytic methods could only be determined after the data had been collected. See *Detection rates*.

RESULTS

Species Accounts

The number of birds recorded, estimated breeding densities, and population sizes for all breeding species (excluding incidental observations) are included in Appendix B, and maps for the most regularly detected species are in Appendix C.

Sample Sizes

During the course of three bird breeding seasons (2012, 2013, and 2014) a total of 312 plots were surveyed using the rapid survey method (Table 1.3). Sixty-seven percent (n=211) occurred on Federal and State lands and 54% (n=169) were in the Upper Sonoran Desert. During rapid surveys, a total of 15,909 birds of 72 species were recorded with an additional 92 species documented only as incidentals. In this report, "N Birds" means number of individual birds, not number of pairs.

A total of 28 plots (9% of 312) were surveyed using the intensive survey method (Table 1.4). Eighty-nine percent (n=25) occurred on Federal and State Lands and 64% (n=18) in the Upper Sonoran Desert. A total of 2,326 birds of 52 species were recorded, excluding incidental observations.

Number of Birds Per Plot

A mean of 51 birds per plot were recorded with 35 birds per plot in the Lower Sonoran Desert and 64 birds per plot in the Upper Sonoran Desert (Table 1.3).

Table 1.3. Sample sizes by ownership and region for rapid surveys.

Land Ownership	N Plots	N Species	N Birds
Federal and State Lands	211	62	11,722
Department of Defense	81	41	2571
Tohono O'odham Nation	15	54	1055
Arizona National Guard	5	31	561
Total	312	74*	15,909
Region			
Lower	143	45	5032
Upper	169	70	10,877
Total	312	74*	15,909

*Totals for N Species do not add up because of species occurring in multiple land ownerships and regions.

Table 1.4. Sample sizes by ownership and region for intensive surveys.			
Land Ownership	N Plots	N Species	N Birds
Federal and State Lands	25	52	2172
Department of Defense	3	15	154
Tohono O'odham Nation	0	0	0
Arizona National Guard	0	0	0
Total	28	52*	2326
Region			
Lower	10	26	318
Upper	18	50	2008
Total	28	52*	2326

*Totals for N Species do not add up because species occurring in multiple land ownerships and regions.

Detection Rates

The overall detection rate (for all species combined) was 0.73 (SE=0.13, CV=0.18). Detection rates for all species combined varied among plots from a low of 0.11 to a high of 4.29. Bird detection rates differed substantially between surveyors.

Species-specific detection rates were calculated for those species recorded at least 20 times on intensive surveys (Table 1.5). The detection rate did not differ significantly from the overall rate (0.73), however, they exceeded 1.0 (e.g., Gila Woodpecker [*Melanerpes uropygialis*]) if more birds were recorded on the rapid survey than were present (during intensive surveys). Also, White-winged Dove (*Zenaida asiatica*, 0.24), Lucy's Warbler (*Oreothlypis luciae*, 0.32) and Lesser Nighthawk (*Chordeiles acutipennis*, 0.37) did have significantly smaller detection rates. For these three species, many individuals were present on the intensive plots and detection rates were consistently low. Therefore detection rates were calculated separately for these species (Table 1.6).

Table 1.5. Detection rates for species on intensive plots with ≥20 individuals recorded.						
Species	N Birds	N Plots	Detection Rate	SE	t value	P value
Black-throated Sparrow	230	28	1.00	0.21	1.30	0.20
Verdin	201	21	0.77	0.18	0.23	0.82
Cactus Wren	186	23	0.68	0.15	0.32	0.75
Black-tailed Gnatcatcher	170	24	0.71	0.16	0.12	0.91
Ash-throated Flycatcher	141	26	0.84	0.21	0.50	0.62
Mourning Dove	130	25	0.72	0.15	0.05	0.96
Gambel's Quail	125	15	1.08	0.39	0.89	0.39
House Finch	124	16	0.89	0.45	0.35	0.73
Canyon Towhee	106	12	0.42	0.12	2.58	0.03
White-winged Dove	100	18	0.24	0.09	5.54	0
Curve-billed Thrasher	95	12	0.71	0.31	0.08	0.94
Lucy's Warbler	63	12	0.32	0.08	5.06	0
Gila Woodpecker	49	13	1.14	0.53	0.78	0.45
Lesser Nighthawk	46	6	0.37	0.07	5.07	0
Phainopepla	45	12	0.89	0.39	0.41	0.69
Ladder-backed Woodpecker	40	14	0.93	0.38	0.51	0.62
Gilded Flicker	36	14	1.08	0.31	1.12	0.28
Rock Wren	35	11	0.80	0.40	0.17	0.86

Brown-crested Flycatcher	30	7	0.67	0.49	0.13	0.90
Loggerhead Shrike	29	12	0.69	0.23	0.17	0.86
Northern Mockingbird	27	11	1.00	0.46	0.58	0.57
Scott's Oriole	20	8	0.80	0.25	0.28	0.79

Table 1.6. Estimated numbers for three species with low overall detection rates.

Species	N Birds	N of plots on which estimate was...		
		Low	Correct	High
Lesser Nighthawk	46	5	0	1
Lucy's Warbler	63	11	0	1
White-winged Dove	100	14	2	2

Densities and Population Sizes

The total number of birds in the study area is estimated at over 30 million (CV=0.19) (Table 1.7). Incorporating the CV into this estimate, the true number is within 38% of 30 million birds (i.e., CVx2x100). However, the sum of the numbers in Table 1.7 does not exactly equal the estimated total number because ratio estimators are being used (Bart et al. 2012).

Table 1.7. Estimated densities and total numbers of birds by land ownership and region.

Land Ownership	N Birds	Density (birds/km^2)	SE (density)	Total Numbers	SE (pop. size)	CV
Federal and State Lands	11,722	449	85	21,537,511	4,091,006	0.19
Department of Defense	2571	221	46	2,332,216	488,662	0.21
Tohono O'odham Nation	1055	601	158	6,366,343	1,670,079	0.26
Arizona National Guard	561	739	206	16,261	4526	0.28
Region						
Upper - normal	9135	551	108	21,078,173	4,142,254	0.20
Upper – rugged edge	1742	575	129	4,665,068	1,047,077	0.22
Lower - normal	4710	197	39	4,206,939	828,935	0.20
Lower – rugged edge	322	287	81	434,343	122,884	0.28
Total	15,909	437	83	30,232,507	5,735,048	0.19

The overall estimated density of birds is 437 birds/km^2. Densities varied between land ownership from 221 to 739 birds/km^2 (Table 1.7). Densities were 560 birds/km^2 in the Upper Sonoran Desert, compared to 200-300 birds/km^2 in the Lower Sonoran Desert.

The species-specific densities and population sizes for 30 species recorded at least 50 times during rapid surveys were calculated (Table 1.8). Estimated densities exceeded 25 birds/km^2 and estimated population sizes of 1.8 to 3.3 million birds for Black-throated Sparrow (*Amphispiza bilineata*), Verdin (*Auriparus flaviceps*), Black-tailed Gnatcatcher (*Polioptila melanura*), Cactus Wren (*Campylorhynchus brunneicapillus*), Ash-throated Flycatcher (*Myiarchus cinerascens*), Lucy's Warbler, and Gambel's Quail (*Callipepla gambelii*), which were the most abundant species. Three other species (White-winged Dove, Mourning Dove (*Zenaida macroura*), and House Finch (*Haemorhous mexicanus*) had estimated densities exceeding 20 birds/km^2 and estimated population sizes of over 1.4 million birds.

Table 1.8. Density and population estimates for the most commonly recorded species.[1]

Species	N Birds	N Plots	Density (birds/km^2)	Population Size	CV
Black-throated Sparrow	1982	252	48.9	3,382,580	0.20
Verdin	1445	215	36.4	2,518,847	0.20
Black-tailed Gnatcatcher	1454	236	36.0	2,488,940	0.19
Cactus Wren	1108	177	32.8	2,269,339	0.21
Ash-throated Flycatcher	1210	246	30.4	2,102,037	0.20
Lucy's Warbler	327	56	28.7	1,983,448	0.28
Gambel's Quail	1083	145	27.2	1,885,159	0.23
White-winged Dove	317	91	21.4	1,780,909	0.20
Mourning Dove	943	177	21.5	1,479,862	0.20
House Finch	879	146	20.5	1,418,759	0.23
Curve-billed Thrasher	622	96	18.0	1,242,181	0.22
Gila Woodpecker	498	112	13.9	958,884	0.22
Phainopepla	588	117	12.6	871,309	0.22
Lesser Nighthawk	132	47	10.6	732,879	0.42
Gilded Flicker	277	93	7.5	518,947	0.23
Canyon Towhee	222	58	7.1	491,460	0.24
Ladder-backed Woodpecker	239	93	6.6	455,207	0.22
Brown-crested Flycatcher	169	36	6.2	432,362	0.27
Northern Mockingbird	267	86	5.7	397,711	0.22
Loggerhead Shrike	263	107	5.0	348,331	0.21
Rock Wren	195	54	4.5	311,007	0.25
Scott's Oriole	108	36	3.3	225,290	0.27
Pyrrhuloxia	81	23	3.2	223,866	0.46
Rufous-winged Sparrow	53	11	2.7	184,874	0.49
Northern Cardinal	66	21	2.3	157,684	0.31
American Kestrel	85	39	2.1	143,929	0.26
Horned Lark	124	28	1.5	102,898	0.29
Greater Roadrunner	51	24	1.2	80,364	0.31
Say's Phoebe	51	24	0.9	61,758	0.29
Le Conte's Thrasher	51	20	0.7	48,402	0.33

[1]Appendix B contains results for all breeding species.

All seven of the most frequently recorded species (Table 1.9) were more common in the Upper Sonoran Desert than the Lower Sonoran Desert. Among all 72 species recorded (Appendix B), only eight were more common in the Lower Sonoran Desert (Table 1.10).

Table 1.9. Densities of the most frequently recorded species in different regions.

Regions	Ash-throated Flycatcher	Black-tailed Gnatcatcher	Black-throated Sparrow	Cactus Wren	Gambel's Quail	Mourning Dove	Verdin
Densities (birds/km^2)							
Upper - normal	36	45	56	46	35	25	47
Upper – rugged edge	41	37	80	34	28	26	37
Lower - normal	16	21	26	9	15	13	18
Lower – rugged edge	29	24	37	27	0	14	25
SEs							
Upper - normal	8	9	12	10	9	6	10
Upper – rugged edge	11	10	23	9	9	8	10
Lower - normal	3	4	5	2	4	3	4
Lower – rugged edge	9	10	12	11	0	7	10

Table 1.10. Species more frequently encountered in the Lower Region than the Upper Region of the Sonoran Desert.

	N Birds	
Species	Upper Region	Lower Region
Anna's Hummingbird	1	4
Eurasian Collared-Dove	1	2
Great Horned Owl	5	10
Horned Lark	6	118
Lark Sparrow	0	1
Le Conte's Thrasher	3	48
Loggerhead Shrike	98	165
Long-eared Owl	0	2
Northern Mockingbird	123	144
Say's Phoebe	16	35
Western Meadowlark	0	16

Drainages vs. Uplands

Desert drainages (i.e., washes or arroyos) typically have flowing water for very short periods immediately following heavy rains. Many of these drainages may only flow for a few hours annually. Although encompassing a relatively small proportion of the overall Sonoran Desert landscape in Arizona, these drainages and their associated denser and taller vegetation are an important habitat component for breeding bird species (Spence and Corman 2015). Many species utilize the drainages and upland habitats equally, others show a clear preference for desert drainages (Table 1.11). These include Crissal Thrasher (*Toxostoma crissale*) and Bell's Vireo (*Vireo bellii*) with 90% (n=38) and 79% (n=26) of records within drainages, respectively. Seventy-eight percent (n=246) of the plots contained at least some drainage habitat.

Table 1.11. Commonly recorded species in Sonoran Desert washes.

Species	N birds			% Desert	% Wash
	Desert	Wash	Total		
Crissal Thrasher	4	38	42	0.10	0.90
Bell's Vireo	7	26	33	0.21	0.79
Western Screech-Owl	10	18	28	0.36	0.64
Hooded Oriole	8	12	20	0.40	0.60
Verdin	621.5	822	1443.5	0.43	0.57
Phainopepla	260	327.5	587.5	0.44	0.56
Black-tailed Gnatcatcher	652	802	1454	0.45	0.55
Lucy's Warbler	159.5	166.5	326	0.49	0.51
Bewick's Wren	11	11	22	0.50	0.50
Pyrrhuloxia	42	39	81	0.52	0.48
Costa's Hummingbird	195.5	158	353.5	0.55	0.45
Northern Mockingbird	157	110	267	0.59	0.41

Species of Special Concern

Seventeen SGCN regularly breed in Arizona's Sonoran Desert, including associated desert washes (Corman and Wise-Gervais 2005). Estimates of density and population size were obtained for nine based on >30 individuals per species (Table 1.12). CVs for these nine were <0.5, and six were <0.3. The eight remaining SGCN are very locally distributed, primarily

nocturnal species, or sparsely distributed. Different methods, such as species-specific or nocturnal surveys, are needed to monitor these seven species breeding populations.

Table 1.12. Density and population size for SGCN that breed in the Sonoran Desert.[1]

Species	N Birds	N Plots	Density (birds/km^2)	Pop. Size	CV
Black-tailed Gnatcatcher	1454	236	36.0	2,488,940	0.19
Phainopepla	588	117	12.6	871,309	0.22
Gila Woodpecker	498	112	13.9	958,884	0.22
Lucy's Warbler	327	56	28.7	1,983,448	0.28
Gilded Flicker	277	93	7.5	518,947	0.23
Brown-crested Flycatcher	169	36	6.2	432,362	0.27
Rufous-winged Sparrow	53	11	2.7	184,874	0.49
Le Conte's Thrasher	51	20	0.7	48,492	0.33
Bendire's Thrasher	34	13	1.0	67,900	0.36

[1]SGCN = Species of Greatest Conservation Need

Incidental Observations

A total of 18,100 birds of 161 species were recorded as incidentals. Four species were recorded >1,000 times, and 19 others more than 100 times (Table 1.13). Most (n=14) of these 23 are wintering or migratory species which do not breed in the Sonoran Desert. However, some (n=9) are common breeders (unshaded in table), but these individuals nested outside the plot boundaries.

Table 1.13. Species recorded >100 times as incidentals.

Species	N recorded
Brewer's Sparrow	3971
White-crowned Sparrow	3299
Tree Swallow	1083
Red-winged Blackbird	1060
House Finch	932
Mourning Dove	787
Lark Bunting	395
Black-throated Sparrow	387
Gambel's Quail	378
Turkey Vulture	354
White-winged Dove	342
Yellow-rumped (Audubon's) Warbler	330
Northern Rough-winged Swallow	299
Common Raven	260
Violet-green Swallow	248
Wilson's Warbler	202
Orange-crowned Warbler	177
Lesser Goldfinch	164
Nashville Warbler	154
Vesper Sparrow	153
Cliff Swallow	153
Western Kingbird	133
Chipping Sparrow	130
Total	15,391

Shading indicates species that are wintering or migratory and which do not typically breed in the Sonoran Desert.

Species Richness

Species richness (i.e., the average number of breeding species recorded per plot) was 12.7, but varied among regions from 7.7 to 13.0 (Table 1.14). Species richness was higher in the Upper Sonoran Desert.

Table 1.14. Mean number of species recorded in different region strata.

Region	N Plots	N Species	SE
Upper - normal	143	12.4	0.48
Upper - rugged	26	13	1.05
Lower - normal	137	7.7	0.38
Lower - rugged	6	11.3	1.36
All Strata	312	12.7	0.45

Nest Site Data of Sonoran Desert Birds

During the Arizona Breeding Bird Atlas (ABBA; 1993-2000), surveyors collected at least partial measurements on substrate type, nesting stage, nest contents, date, coordinates, and other information at approximately 3,500 nests of 184 species across the state (Corman and Wise-Gervais 2005). During this study, similar data was opportunistically collected at active nests to expand on the ABBA dataset.

Nest site data was collected at approximately 875 active nests of 38 Sonoran Desert species, with number of nests for the top ten species reported below (Table 1.15). Surveyors most commonly encountered nests of Mourning Doves, however, surveyors were asked to focus on other species.

Table 1.15. Top ten species for which nest site data were collected.

Species	N Nests
Cactus Wren	123
Verdin	108
Curve-billed Thrasher	85
Black-tailed Gnatcatcher	50
Gila Woodpecker	44
Black-throated Sparrow	42
House Finch	40
Mourning Dove	37
Ash-throated Flycatcher	23
Phainopepla	21
Total	573

As noted in the ABBA (Corman and Wise-Gervais 2005), nest site characteristics and breeding phenology data (i.e., date, nest content, number of eggs/young) are more useful to land and wildlife management agencies because they were collected in Arizona. New records can be compared to historic data to look at possible breeding phenology and nest substrate changes. For example, three separate nests of Costa's Hummingbirds (*Calypte costae*) were discovered in Elephant trees (*Bursera microphylla*), which was not reported in the ABBA.

Habitat Assessment

Invasive Plants- To assess the prevalence and distribution of invasive grasses and forbs, surveyors noted the presence of: Sahara (Asian) mustard (*Brassica tournefortii*), buffelgrass (*Pennisetum ciliare*), crimson fountaingrass (*Pennisetum setaceum*), red brome (*Bromus rubens*), Mediterranean grass (*Schismus sp.*), Bermudagrass (*Cynodon dactylon*), and prickly Russian thistle (*Salsola tragus*). Of these, surveyors encountered Sahara mustard and Mediterranean grass on 22% and 15% of the plots, respectively (Table 1.16), and red brome and buffelgrass on 12% and 8% of plots, respectively. Sahara mustard occurred on nearly twice as many plots in the Lower Sonoran Desert, even though more plots were surveyed in the Upper than the Lower Sonoran Desert.

Table 1.16. Number of surveyed Sonoran Desert plots with select set of invasive, exotic plant species.

Land Ownership	N Plots	Sahara Mustard N (%)	Red Brome N (%)	Buffelgrass N (%)	Mediterranean Grass N (%)	Bermuda-grass N (%)	Fountain-grass N (%)	Russian Thistle N (%)
DoD	86	23 (27)	2 (2)	7 (8)	8 (9)	0	0	7 (8)
Other	223	46 (21)	34 (15)	17 (8)	39 (17)	10 (4)	5 (2)	10 (4)
Region								
Lower	143	42 (29)	1 (<1)	19 (13)	16 (11)	1 (<1)	1 (<1)	13 (9)
Upper	166	27 (16)	35 (21)	5 (3)	31 (19)	9 (5)	4 (2)	4 (2)
Total	309	69 (22)	36 (12)	24 (8)	47 (15)	10 (3)	5 (2)	17 (6)

Habitat Disturbance- During year two and three of the study, surveyors noted any disturbances on plots, such as OHV and livestock use, and burned areas, newly established roadways, camping sites, and other developments. Of all plots, 45% (n=95) had OHV use, 36% had livestock use (n=77) and 2% (n=4) showed evidence of being burned (Table 1.17). Of interest, OHV use was found on over half the plots on DOD lands, an area with restricted public access.

Table 1.17. Number of surveyed Sonoran Desert plots with landscape disturbances reported.

Land Ownership	N Plots	Burned N (%)	OHV N (%)	Livestock N (%)	Other Disturbance N (%)
DoD	64	2 (3)	35 (54)	8 (12)	6 (9)
Other	149	2 (1)	60 (40)	69 (46)	20 (13)
Region					
Lower	104	3 (2)	60 (58)	20 (19)	15 (14)
Upper	109	1 (1)	35 (32)	57 (52)	11 (10)
Total	213	4 (2)	95 (45)	77 (36)	26 (12)

Accuracy of the Point Estimates of Density and Population Size

The calculated CVs for density and population size was ≤0.25 for 18 of the 30 most-commonly recorded species (Table 1.8). If bias is negligible and the distribution of the estimate (across repeated samples) is approximately normal, a conclusion can be made that the true population size is within the interval bounded by the estimate times 1 ± 2CV (i.e., with 95% probability). For example, the estimated population size for Black-throated Sparrow is about 3.4 million with a CV of 0.2. This means that if bias is negligible then the true population size in the study area is estimated between 3.4 x (1-2[0.2]) = 2.0 and 3.4 x (1+2[0.2]) = 4.8 million birds.

Substantial effort was made to estimate detection rates using intensively surveyed plots to substantiate that the point estimates of density and population size have small biases. The expected value of an estimate calculated using the standard formulas for double sampling equals the expected value of the estimate made on the intensive plots. Thus, if counts on the intensive plots were accurate (i.e., have no measurement error), then the estimates in this report were unbiased. Furthermore, the counts remain unbiased if the intensive surveys were sometimes inaccurate but were as likely to be high as to be low (or more precisely, were unbiased). The intensive plot approach has shown to yield nearly unbiased counts in studying arctic shorebirds (Smith et al. 2009). Recently researchers also evaluated intensive surveys for birds on the lower Colorado River and showed that the surveys recorded most birds (≈84% of territories) except on plots with high density of birds and very dense vegetation (GBBO 2013).

An evaluation of the intensive methods (Chapter 2) provided rigorous estimates of how much detection rates varied in this study. The variation was larger than expected, but the results still provide better estimates of population size than studies in which detection rates were not rigorously estimated. The reasons for the variation in detection rates, and recommendations for improving the intensive methods to obtain better estimates are included in Chapter 2.

The distributional assumption is that the estimate would have a normal distribution in repeated sampling (using the same sampling plan and sample size). There is a mistaken belief the underlying counts must be normally distributed. This condition (normal distribution of the individual counts) is sufficient to insure that the estimate also has a normal distribution. However, with a sufficiently large sample size, estimates from any distribution become close enough to normal for practical purposes (Snedecor and Cochran 1967). This study's estimates were based on 312 plots. This is larger than what is generally needed to assume the estimates are normally distributed. Cochran (1977), for example, presents an example of selecting cities randomly from a population in which more than half the cities had populations of <100,000 but four cities had populations of several million each. Even in this extreme case, a sample of size 49 was shown to have an approximately normal distribution. Stratification, which segregates plots with unusually high or low numbers in one or a few strata, reduces non-normality. For most of the species of interest reported, the assumption is the estimates are normally distributed. The exceptions would be rare, locally distributed, or semi-colonial species. The assumption is the estimates and confidence intervals have low bias, except for some uncertainty about accuracy of the intensive surveys (Chapter 2).

Recommendations

Four questions arise for consideration for conducting future surveys:

- Should the same plots be re-surveyed?

Although selecting the same plots during each survey period may provide the highest power (Cochran 1977), selecting new plots each survey period will allow surveyors to become more informed about the survey areas and give more flexibility in the design. For example, a different stratification system may be used to take advantage of greater understanding about patterns in abundance. Re-stratifying is difficult – and in some cases impossible – if the same plots are visited in each round of surveys. Therefore new plots should be selected in each survey period.

- How many plots should be surveyed?

With two independent samples and each having a CV of 0.31, power is 80% to detect a decline in abundance of 50% (Bart et al. 2012). In this first survey period, 312 plots were surveyed and CVs for the estimated population size were ≤0.31 for 26 species (Table 1.8) including six species on the SGCN list (Table 1.12). While higher accuracy is desirable, there is a reasonable compromise between accuracy and cost. Therefore future rounds of surveys should also have 300 plots (i.e., 100 plots per year during a 3-year round of surveys). If improved training of surveyors is implemented, then the CV of the estimated detection rate will presumably decline. If it declines by 50%, then the number of rapid plots could also be reduced by 50% without reducing precision of the overall estimates.

- When should the next set of surveys be conducted?

If only three years elapse between surveys, then surveys in the Sonoran Desert are being made in half the years (Figure 1.7). This is prohibitively expensive. Therefore, unless other evidence suggests that desert birds are declining, five or six years between surveys would be preferable (red and green options). With any of the four approaches examined, three survey periods would be completed in 21 years.

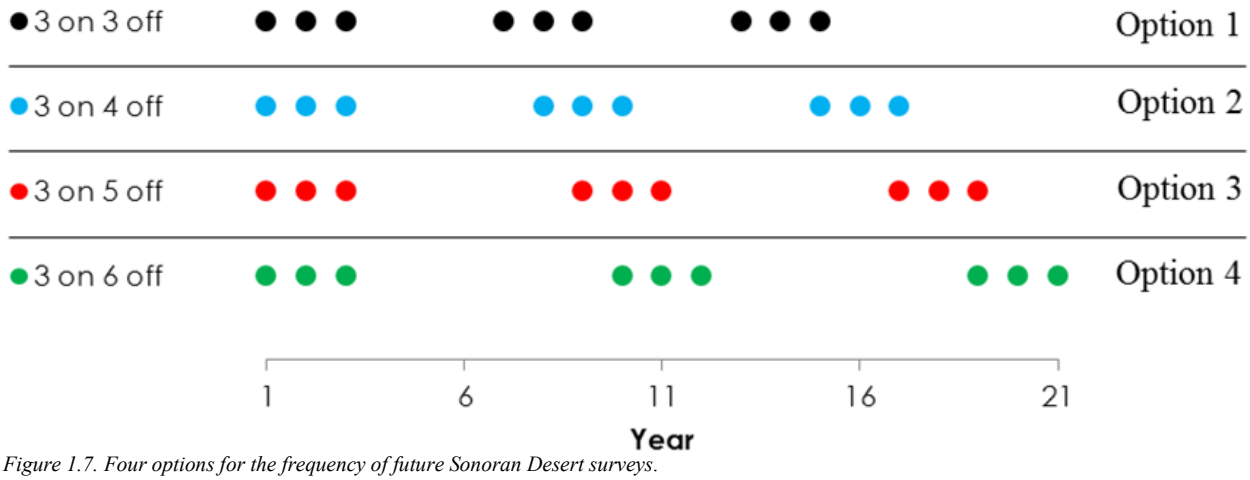


Figure 1.7. Four options for the frequency of future Sonoran Desert surveys.

- Should more intensive surveys be conducted?

Another issue is whether the intensive surveys should be repeated. The alternative is to use the detection rates from the present study. The advantage of not repeating the intensive surveys is a substantial reduction in costs (i.e., if the number of rapid plots is kept the same). The disadvantage is that differences in survey results could be attributed to change in detection rates rather than change in population size. Several factors could cause detection rates to differ between surveys:

a) Surveyor behavior. If surveyors differ substantially in detection rates, then the overall efficiency could be affected by how surveyors conduct the surveys.
b) Different breeding phenology or weather during the surveys.

On the other hand, if the surveys are conducted three times during a 21-year period, then it is less likely that bias in the trend estimate would arise from these factors. If there is considerable interest in estimating change in population size after just two periods, then the intensive surveys should be repeated. If intensive surveys are repeated, then supplementary data such as nesting success, breeding phenology, and detailed habitat associations should be collected.

In summary, survey methodology should follow a design where new plots are selected for each survey period (1 survey period = 3 breeding seasons), survey 300 plots per period, and allow a five or six year elapse between survey periods.

CHAPTER 2: EVALUATION OF THE INTENSIVE SURVEY METHOD IN THE SONORAN DESERT BIRD SURVEY

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INTRODUCTION

Bird monitoring should include efforts to estimate detection rates whenever feasible (Williams et al. 2002). Unbiased estimates of detection rates ensure unbiased estimates of population size (and trend) which are more useful than index results. Without estimates of detection rates, it is often hard to be certain how much of a trend in results might be due to a trend in the detection rate rather than a trend in population sizes. For example, surveyors may have become more experienced through time or their training may have improved, habitat may have changed affecting detection rates, or phenology may have changed due to climate change. Unless all possible changes that might have caused a trend in detection rate can be eliminated *a priori*, it is difficult to be certain that observed changes in survey results indicate change in population size rather than change in detection rates.

Researchers use several methods in bird surveys to estimate detection rates (Gitzen et al. 2012). Distance methods (Buckland et al. 2005), double observer methods (Nichols et al. 2000), removal methods (Farnsworth et al. 2002) and double sampling (Cochran 1977, Bart and Earnst 2002) are among the most widely used. In double sampling, researchers use a rapid survey method – of unknown accuracy – on a large sample of plots and survey a subset of those plots using an intensive method that is assumed to generate unbiased estimates. Researchers use the ratio of the counts from the rapid surveys on this subset of plots to the true numbers present on these same plots – as determined by the intensive surveys – to adjust rapid results from the large sample of plots and obtain the estimate of population size.

In double sampling, the expected value of the estimate equals the expected value of the intensive counts (Cochran 1977). For example, if the intensive counts under-estimate the number of birds present on plots by 10%, then the expected value of the estimated population size will be too low by 10%. It is therefore important to verify that the intensive counts are approximately unbiased. Smith et al. (2009) investigated this issue, who studied the intensive methods used on double sampling surveys in the Arctic. Smith et al. applied the intensive methods to a set of plots where each plot was searched independently by at least two surveyors, and results compared at the end of the season. Smith et al. found that the intensive methods detected most birds with high probability, but birds might be missed if their nests failed quickly and they left the plots. The study, however, judged the estimates, to be within 15% of the true values for most species.

Researchers have used double sampling extensively in Arizona during the past several years. Researchers in Arizona have conducted two evaluations (one in riparian and another in Sonoran Desert habitats) of the intensive methods. On the Lower Colorado River an evaluation found the intensive surveys recorded most of the birds (≈84% of territories) on plots (GBBO 2013). But the study did suggest that in hard-to-survey intensive plots with high bird densities and very dense vegetation, surveyors recorded fewer birds than may be present. Overall, the Lower Colorado

River study confirmed that the double sampling approach was meeting the monitoring needs of the project, while noting that some species (e.g., Black-chinned Hummingbird [*Archilochus alexandri*] and Summer Tanager [*Piranga rubra*]) may need special consideration because their natural history makes them difficult to survey. The second evaluation (in Sonoran Desert habitat) is described below.

METHODS

To conduct the evaluation, plots were surveyed independently by two surveyors using the intensive method described in Chapter 1.

Two independent series of intensive surveys were made on each of four plots in 2013 and on each of four different plots in 2014 (the effort was termed "double intensive surveys"). There were a total of seven surveyors, four in 2013 and three in 2014. Surveyors visited plots in the Upper Sonoran Desert eight (in 2013) or 16 (in 2014) times and plots in the Lower Sonoran Desert six (in 2013) or 12 (in 2014) times. The number of visits in 2014 were increased to reduce the chances of missing birds breeding on the plot. In 2014, surveyors were selected based on prior experience with the study and given more extensive training.

Using the study described in Chapter 1, at the end of each field season, results were compared from the two intensive surveyors. The number of species recorded by either surveyor on each plot and the difference between estimated numbers present for the two surveyors were determined. Ideally, the species lists and numbers of each species would be identical. Departures from this ideal was used to evaluate the accuracy of the intensive surveys.

RESULTS

As an example, the results for one plot is included in Table 2.1. The two surveyors estimated the numbers of birds to be present at 25 and 19. Much of the difference occurred due to the surveyors' estimates of Black-throated Sparrows by four. The absolute difference in estimates was calculated at ≤2 for each of the other seven species, and the average difference at 0.75 (0.29 removing Black-throated Sparrows). Thus, for seven of the eight species, estimates by the two surveyors were within one pair (i.e., two birds).

Table 2.1. Summarized results for select birds from plot 46689 surveyed in 2014.

Species	Surveyor		Difference
	1	2	
Ash-throated Flycatcher	2	1	1
Black-tailed Gnatcatcher	3	3	0
Black-throated Sparrow	10	6	4
Crissal Thrasher	0	2	-2
Lesser Nighthawk	1	2	-1
Lucy's Warbler	5	3	2
Mourning Dove	2	0	2
Verdin	2	2	0
Totals and Average Difference	25	19	0.75

Results for eight plots showed a wide range in number of birds recorded (19 to 318 birds) (Table 2.2). Larger differences were documented between surveyors in 2013 than in 2014 (average difference of 74 vs. 18), indicating the effectiveness of the additional training in 2014. The average differences were calculated at <3.0 for six of the eight plots and with smaller differences in 2014 than 2013 (Appendix D). Results showed differences between counts for individual species as generally ≤3.0, though several differences were much larger in 2013 (Table 2.3).

Although numbers varied substantially among species, there was no clear evidence of differences in how difficult different species were to detect (Table 2.4). Ten species were recorded on at least five plots, and while the average absolute difference in numbers recorded varied from 5.6 to 1.5, none of the differences were significant (e.g., the *t*-value for the largest value minus the smallest value was only 1.29).

Table 2.2. Number of birds recorded on eight plots by surveyor and average difference per species.

Year	Plot	Surveyor					Difference	Average Difference
		1	2	3	4	5		
2013	2249	50	70	-	-	-	20	-1.3
2013	4289	-	238	-	318	-	80	-4.0
2013	35860	126	183	-	-	-	57	-2.6
2013	92197	-	-	-	243	106	137	5.7
2014	8177	39	-	70	-	-	31	-2.8
2014	46689	25	19	-	-	-	6	0.8
2014	81232	14	-	24	-	-	10	-1.1
2014	90921	-	21	44	-	-	23	-2.1

Table 2.3. Frequency distribution of counts per species in 2013 and 2014.

Absolute Difference	2013	2014	Both
0	6	7	13
0.5	1	0	1
1	9	7	16
2	25	16	41
3	3	3	6
4	9	3	12
5	3	2	5
6	5	0	5
7	3	0	3
8	4	1	5
9	2	0	2
10	4	0	4
11	2	0	2
12	0	0	0
13	2	0	2
14	1	0	1
15+	2	0	2
Totals	81	39	120

Table 2.4. Average absolute differences in number of select species recorded on ≤ five plots.

Species	Average absolute difference	Number of plots	SE
Verdin	5.6	8	3.1
Gambel's Quail	5.4	5	1.2
White-winged Dove	5.3	6	1.3
House Finch	5.2	6	1.8
Mourning Dove	4.7	7	1.8
Black-throated Sparrow	3.3	8	0.5
Ash-throated Flycatcher	3.0	8	1.3
Black-tailed Gnatcatcher	2.4	8	0.7
Crissal Thrasher	2.0	5	0.3
Lucy's Warbler	1.5	6	0.7

DISCUSSION

Results of the double intensive surveys showed smaller differences in counts in 2014 than in 2013 (Table 2.2). These differences were primarily due to Surveyor 3 consistently recording more birds than Surveyor 1 or Surveyor 2. The differences would have been less in 2013 if training had been more extensive, and in 2014 if more surveyors had conducted the double intensive surveys. Some of the differences were likely due to variance in interpretation. For example in 2014, Surveyor 3 recorded substantially more individuals of several species than did Surveyor 1 or Surveyor 2 (Table 2.5). But in 12-16 visits, it seems unlikely that Surveyor 1 and Surveyor 2 detected fewer birds than Surveyor 3. It is more likely that the surveyors saw about the same number of birds, but interpreted their observations differently. This apparent difference in interpretation does not indicate intensive surveys for the study (28 plots; Chapter 1) were unreliable, as it had a robust sample size (e.g., more intensive plots and surveyors). But it does show the need for more intensive training and continuous communication with the field surveyors on maintaining a standardized interpretation of observations to reduce these variations.

Table 2.5. Comparison of numbers of common species recorded on selected plots in 2014.

Plot	Species	Surveyor 1 or 2	Surveyor 3	Difference
8177	Mourning Dove	5	13	8
8177	Gambel's Quail	0	5	5
90921	Black-throated Sparrow	4	9	5
8177	Black-tailed Gnatcatcher	5	9	4
90921	Rock Wren	1	5	4
	All	15	41	26

The difference in estimates translates directly into variation of the estimated population size. For example, the average of the counts in 2014 by Surveyor 3 was about twice the average value of Surveyor 1 and Surveyor 2. Consequently, if one were to estimate the detection ratio from Surveyor 3 data, the population estimate would be about twice the value that would be obtained using data from Surveyors 1 and 2. The discrepancy between surveyors causes considerable uncertainty in the estimated population size and raises the possibility that, over time the average estimate on intensive surveys might change (e.g., due to better training), even if population size did not actually change.

The intensive plot approach has shown to yield nearly unbiased counts in studying arctic shorebirds (Smith et al. 2009). More recent research evaluated intensive surveys for birds on the lower Colorado River, and showed the surveys recorded most birds (GBBO 2013). The evaluations in the artic and Colorado River have shown the intensive method works well, except in areas like the Bill Williams River, where very dense vegetation and extremely high bird density presented surveying challenges (GBBO 2013). Those conditions did not occur in this study. Therefore, the double intensive surveys yielded accurate estimates of the detection rates even though the small sample of intensive surveyors did show considerable variation. With a more robust sample size (e.g., more double intensive plots and surveyors), this study would have shown much more consistent results.

In summary, the double intensive study provided rigorous estimates of how much detection rates varied in the Sonoran Desert surveys. There was a larger variation than expected, but the results still provide better estimates of population size than other studies in which detection rates were not rigorously estimated.

RECOMMENDATIONS

Results from the double intensive study suggest several ways to improve the repeatability of intensive surveys.

- Training of intensive surveyors should begin as soon as birds become active. The surveyors would initially visit plots together as a training exercise. On the first day, they would begin working together, but independently assessing evidence they encounter. After a few hours, they would independently summarize their observations and make their best estimate of numbers present. They would then compare their results, talk about discrepancies, and re-survey the plot to resolve differences in interpretation. In this manner, they would be consistent and minimize differences in interpretation. After two days, they would survey a single plot independently for 2-3 days. After comparing results, they would again survey the plot together to resolve any lingering discrepancies in estimates. This intensive training should significantly improve the repeatability of the intensive surveys.
- When family groups are encountered, it is difficult to determine whether the nest is in the plot, particularly when it is close to the edge. Accordingly, intensive surveys should start earlier than the rapid surveys, so that intensive surveyors would encounter all breeding birds during their nesting period (i.e., nest construction, incubation, and raising nestlings) before nestlings have fledged. Rapid surveyors should be told to estimate the number of birds on the plot for these species (e.g., rather than using nests times two). Intensive surveyors should also estimate the total number, then the same estimation methods could be used for these non-monogamous species.
- Consider whether to exclude difficult to survey species from analysis, or to explore whether species with similar behavior and ecology have similar detectabilities and group these by “detectability guilds” (GGBO 2013).

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APPENDIX A: SONORAN DESERT BREEDING BIRD SURVEYS FIELD MANUAL

Note: the field manual included is included as originally written. However the *Introduction*, *Goals and objectives* of AZCBM, and *Study Area and project overview* are dated. Please refer to the main report for current information.

Sonoran Desert Breeding Bird Surveys
Field Manual

All Photos by Bruce Taubert

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Introduction

Arizona is undertaking a statewide Coordinated Bird Monitoring (AZCBM) program under the guidance of the Arizona Bird Conservation Initiative (ABCI). This program is similar to other Partners in Flight - Western Working Group state bird monitoring efforts (e.g., Idaho, Nevada, Utah, and Colorado). The main goals are to provide long-term statewide population trend data for species where this information is limited and evaluate the effects of management actions and stressors.

Goals and Objectives of AZCBM

Coordinated bird monitoring programs are usually designed to address several goals:

1. Identify species at risk or of concern
2. Help identify causes of declines or other trends of concern
3. Help design, evaluate, and refine management programs
4. Document recovery, other successes, or continued problems

The long-term goal of the AZCBM Program is to monitor and determine population trends for all bird species throughout the year, as constrained by resource limitations. The current project, however, is focused on the breeding season and primarily on breeding birds within Sonoran Desert habitats.

The objectives of the current project are to estimate density and population size and determine population trend of bird species that breed within Sonoran Desert habitats in our study area and to elucidate relationships between breeding birds and their habitats.

This document describes methods for the Sonoran Desert Breeding Bird Survey. Rapid area search methods are typically used for monitoring bird populations across large geographic areas and different habitat types. A disadvantage of many rapid methods is that they may provide only an index of bird abundance. Rapid surveys may also result in biased estimates of birds which are poorly detectable because they have a soft song, vocalize rarely, behave secretively, show strong seasonal changes in detectability or are temporarily undetectable because they are actively nesting or are foraging outside of their territory.

To obtain an estimate of these biases, intensive area searches can be used in a double-sampling approach (Bart and Earnst 2002). Intensive area searches are used primarily for two purposes, obtaining unbiased bird density estimates and inventorying and monitoring of high priority sites. An unbiased density estimate can be used to generate correction factors for density estimates obtained with rapid area search methods (Bart and Earnst 2002).

Methods

Study area and project overview

The study area in southwestern Arizona includes native Sonoran Desert habitats such as dry (ephemeral) washes, mixed desert scrub, creosote-bursage flats, and other habitats. Primary areas excluded from the sample selection process were private lands, perennial and intermittent riparian corridors sampled by other programs, sections of Department of Defense lands due to safety issues, some tribal lands, and urban, residential and agricultural lands. GIS layers were used to identify the distribution of native desert habitats to be surveyed. Selected plots are then sub-divided by the individual conducting the survey into "desert" and "wash" habitat based on vegetation density and structure. Birds will be assigned to these habitat types based mainly on where they are first detected (see detailed instructions later in this manual). This approach will allow a detection frequency estimate to be made of each bird species breeding in desert versus wash habitats within the plots.

The study area was stratified using land ownership, road access, and habitat. The ownership categories were tribal and all public lands of Arizona. Plots for potential selection were constrained to be within 3 km of an established road including many mapped, local two-tracks. The habitats were designated as either Lower or Upper Sonoran Desert based on GIS habitat layers. Ownership and road access were delineated using standard GIS layers and those provided by various land managing entities.

The goal is to survey approximately 100 plots each year during the three-year survey period. Surveys will be conducted during the first 4-5 hours of daylight and each plot will cover 16 ha. (Upper Sonoran plots) or 24 ha. (Lower Sonoran plots).

Double sampling methodology is being used to determine detection probability. In double sampling a large sample of plots is surveyed using a rapid method of unknown accuracy. Then a randomly selected subsample of surveyed plots is also surveyed using an intensive method to determine true numbers present (i.e., a census). The ratio of the rapid survey results, on intensive survey plots, to the true numbers determined by the intensive surveys provides a "detection ratio" that is used to adjust the results of all rapid surveys.

Rapid Surveys – Detailed Instructions

Field Gear and Materials Checklist

- Binoculars
- Daypack
- Small notebook
- First aid kit
- Plenty of water (minimum 1 gal. per day per person)
- Watch
- Compass
- Thermometer
- GPS unit set in advance to UTM NAD83 and extra batteries
- Broadcast device w/speaker and extra batteries
- Tape Measure (with Meters)
- Laser rangefinder (highly recommended)
- Diameter tape (recommended)
- Camera (if available for photos of plot)
- Cell phone and/or SPOT (satellite GPS messenger)
- Clipboard
- Several pencils and pens (black and red)
- Data forms (*extra copies), Maps and References:
    1. Area Search map (with aerial photo)
    2. Blank Area Search map (with vertices A-L and vegetation points 1-6)
    3. List of plot UTMs with vertices (A-L) and vegetation points (1-6)
    4. Vegetation forms*
    5. Visit Summary forms*
    6. Le Conte's Thrasher survey forms*
    7. Final Summary forms* (last visit only)
    8. Lists of species codes for birds and vegetation
    9. Protocol/Instructions

Plot Access – For each plot, you will be provided several maps including a color geo-referenced aerial photograph of the plot and an Area Search map outlining the plot. A separate page will include UTM (NAD 83) coordinates for the plot corners; various grid intersects (vertices), and points within the plot for conducting vegetation surveys. Though most plots will be within UTM Zone 12, some plots in far-western Arizona will be in UTM Zone 11. Prior to departing from home or office, estimate travel time to your plot, including time spent hiking from your vehicle and taking weather into consideration. It is strongly suggested to conduct a reconnaissance of the plot before conducting the first survey (e.g. the evening before conducting the first survey). Without a prior visit to the plot, you may encounter one or more access issues such as poorer road conditions than expected, unforeseen locked gates, or steep topography.

Survey Dates and Timing – Because the goal is to determine the number of breeding territories/pairs for each species within the plot, each plot must be surveyed twice during the

breeding season (or three times for plots in the southeastern corner of the Sonoran Desert (Table 1). Multiple surveys over the breeding season provide surveyors the opportunity to detect early and late breeders in a given plot. Try to document all breeding individuals/pairs of each species during your first survey; subsequent survey(s) only add NEW individuals/territories or update to a higher confirmation levels of breeding activity for previously detected individuals/pairs.

Three surveys are typically needed if your plot is in sections of Pima and Pinal Counties, or local areas of adjacent counties. For Rapid Surveys, each survey should be separated by at least 21 day and should occur within the following survey periods:

Table 1. Sonoran Desert survey periods.

Sonoran Desert	**First Survey Period**	**Second Survey Period**	**SE Regional Plots**
Lower	1 February to 15 March	16 March to 30 April	
Upper	15 March to 20 April	21 April to 30 May	
Upper	15 March to 20 April	21 April to 30 May	15 July to 15 August

The same single surveyor should conduct both (or all three) surveys for the plot, although for safety reasons, a second person is allowed if both remain together during the survey or clearly survey different sections of the plot. The key is to not double count any birds or territories.

Weather and Surveys – Typically, wind and rain greatly reduce the detectability of birds. Not only do birds vocalize and move (e.g., actively forage) less during inclement weather, but the movement and sound of swaying leaves and branches impairs your ability to hear bird vocalizations and reduces your ability to find, identify, and follow birds in the vegetation. Therefore, surveys should only be conducted when wind speed is <12 mph/ <20 km/hr (12 mph = small trees and leaves sway) and not during periods of sustained rain or heavy fog (we know it is the desert, but it could happen…).

Conducting an Area Search – Begin your Area Search survey 30 minutes before dawn whenever possible; however, we realize that safety or logistic considerations may require a later start. Plan to spend roughly four to five hours conducting the survey. Your day in the field may last up seven hours, especially on the day you record the habitat measurements, so recognize that weather conditions may change during the day and plan accordingly.

To begin your Area Search take out your Visit Summary Form. At the top of the Visit Summary Form write the *plot #, date, surveyor name, start time, start temperature, percent cloud cover, wind, and precipitation data*. Next, take out the *blank* Plot Map with a grid outline. On the blank plot map, use the four-letter codes and the abbreviations page provided. Along with the correct abbreviations, record the identity and location of adult birds on the blank Plot Map. Record birds at their location before they move in response to your presence. When your area search concludes, get out the Visit Summary Form again to record your end time and current weather conditions.

During the "area search," *cover the entire plot* making an effort to pass within 50 meters of every point in the plot. Feel free to spend more time where more birds are (or you believe might be) present. While there is no time limitation on this survey, you should be able to cover the entire

plot during the prime time for bird activity, early to late morning. You do not need to walk at an even pace; feel free to linger in a particular area to answer a question about a particular bird or territory. However, the time spent at a particular spot must be balanced with the need to finish the entire plot before bird activity greatly declines (approximately four or five hours after sunrise, or by 10-11 a.m.). At some point, you may need to move on without having determined breeding status for an individual or pair in order to finish surveying the entire plot. However, feel free to return to that spot after the survey to try to clarify the breeding status.

Be aware that there is a subset of selected plots that are listed as "edge". These are typically plots that include a small percentage of inaccessible sections that are too steep to safely maneuver through the area. These plots are usually misshapen and slightly smaller as the perceived inaccessible section has been removed.

To help you stay on schedule, you may want to divide your plot into sections and decide how much time you can spend in each section. On your plot map, you will see that your plot is divided into sections of four hec (a square with 200 m sides). If you decide to linger in a particular area, use the map to get a sense of how much ground you still must cover and set a time for when you should move on. Feel free to record birds for a few minutes from a given location, such as on top of a small hill or ridge that allows a wide view of the plot. This method can help you determine the number of distinct breeding pairs in your plot, delineate boundaries between bird territories, or watch birds as they fly across your plot toward a favored perch or nest.

Another method that may help is to gradually cover your plot from East to West, keeping the sun behind you in order to reduce the number of "backlit" birds you encounter. However, this may introduce bias (you may spend too much time in the eastern portion of your plot during the peak hours of bird activity), so please account for that.

Habitat Zones – Your plot may include sections of open desert, denser and taller vegetation along dry washes or even areas lacking any vegetation. Please assign each bird detection to one of three "zones" (Table 2). In most cases, simply record birds in the habitat on the basis of where you first see them or where they are spending most of their time. If they are in wash/arroyo habitat within the plot, record them with a "W" for wash. However, you may recognize that a bird or a flock is using the area only as a migrant stop-over rather than breeding. In this case, record the birds as an "I" for incidental. You might also see a bird that you know breeds in a habitat that does not occur within the plot (e.g., cliffs, adjacent riparian). It would be appropriate to record such birds as incidental.

Table 2. Habitat zones, codes, and definitions.

HABITAT ZONES		
Code	**Definition**	**Clarifications**
W	Wash	breeding in the plot in desert wash habitat (typically taller and denser vegetation)
D	Desert	breeding in the plot in open desert, away from wash vegetation
I	Incidental	presumed to be nesting outside the plot or considered a migrant only

Breeding Status – The goals of your Area Search is to classify each bird you detect within your plot into one of the Observation Types (Table 3), and to record the highest level of breeding evidence observed for each individual or pair detected. For each adult bird, determine if it is a lone individual or is part of a breeding pair. The two-letter codes in the Occupied Nest category (NB, NE, NY, DD, and FY) are to be used only if you have confirmed breeding. Use PN if nesting is likely but undetermined. During your first survey, make your best effort to find and categorize all birds within your plot. During your second (or third) visit, make an effort to 'upgrade' the breeding status of birds you found during your previous visit(s). Upgrading, for example, an individual male (M) and an individual female (F), both found during your first survey, into a pair (P) or occupied nest (ON) during your second visit provides more valuable and accurate data and should be one of your goals.

Table 3. Breeding status codes and definitions.

OBSERVATION TYPE		
Code	**Definition**	**AZ Breeding Bird Atlas Examples and Clarifications**
ON	Occupied Nest (confirmed breeding)	Could also use the following codes if known: nest building (NB), nests with eggs (NE), nests with young (NY), distraction display (DD), adult feeding flightless fledglings (FY)
PN	Probable Nest	adult consistently flies into the same likely nest site, but nest structure can't be seen
P	Pair	male and female seen together or within one presumed territory
M	Male	male observed or heard singing, but no female detected
F	Female	female observed or heard calling, but no male detected
U	Unknown Sex	used only for adults of species where sexual dimorphism is not readily apparent
#	Group Number	document the actual number of individuals in flock, typically for migrants and for all adult nonbreeding individuals (do not use for family groups or juveniles)

Family Groups and Juveniles – Please note, if you observe a family group such as an adult female and three begging dependent fledglings that you determined likely nested nearby within the plot then the code used would be "ON". Juveniles or fledglings capable of sustained flight *should not be included on the Survey Summary forms*. They are not part of the breeding population, but a successful outcome of a breeding pair on or near the plot. Although you may be tempted to list them as "Unknown Sex" or Group #, these codes were not established for young of the year or non-breeding juveniles so please do not include them.

Migrants and Flyovers – Each surveyor will likely encounter several individuals or flocks of birds within or flying over the plot that are determined to not nest within the plot because they are either migrants or are nesting outside the plot boundaries. If you are unsure if a particular observation is a migrant then please record the location (a point or a polygon) of the bird in question on your maps and try to make a determination about this bird during your next or final visit. You will often not know for sure that they are migrants until the end of the season, when you realize that they were only on the plot briefly and didn't display any sustained territorial behaviors. Birds determined to be migrants are noted as incidentals (I) and should be transferred over to the Final Summary data form which is completed soon after the final survey. Their presence provides us with useful information about migration chronology and about important habitat use and locations for migrants. The Arizona Breeding Bird Atlas (Corman and Wise-Gervais 2005) is useful for determining if a species should be classified as a migrant based on timing, elevation, and habitat.

Birds flying over the plot that are not actively using the plot do not need to be recorded on the plot map, but should be recorded along the edge of the plot map as incidental (I). Typical flyovers in Arizona include vultures, raptors, ravens, swifts, and swallows. However, if you discover a nest or observe them loafing in a plot that contains appropriate nesting habitat, they are of course recorded in the same manner as all other active users of the plot. Some "flyover" species cause confusion. Birds that are actively foraging or conducting courtship flights (e.g., swallows, hummingbirds) over the plot should not be recorded as flyovers, but as active users of the plot instead and would be denoted with the habitat code (D or W) for the area over which the bird spent the most time. For Upper Sonoran plots, recall that the Desert Purple Martin, a subspecies of high research and conservation interest, nests locally in saguaro cavities; please be observant and patient if you see Purple Martins over your plot and watch for a flying martin to spend time over or land at a large saguaro with suitable cavities. Please note there is also a small, primarily Mexican subspecies of Violet-green Swallow that has also been occasionally documented nesting in saguaro cavities in the Organ Pipe Cactus National Monument region.

Mapping Detections - For all records of birds determined to likely be nesting on the plot, record each detection on the plot map outline using its four-letter bird code (Appendix A), the (habitat) zone, and the type of observation. Each complete observation thus has three parts (species, zone, type). As examples: "CRTH-W-M" indicates a male Crissal Thrasher in the wash zone of the plot. "ROWR-D-ON" means an occupied nest of a Rock Wren discovered in desert habitat within the plot. "BRSP-I-10" means a flock of ten Brewer's Sparrows judged not to be breeding within the plot (even though they might have been seen and heard singing within the plot).

Place a dot on the map indicating the approximate location of the detection and with a connecting line, print the appropriate series of codes documenting the detection. Please make sure the letters are large and dark enough to be read easily even after some fading occurs (a few people tend to write in extremely small, faint letters that are virtually impossible to read; if you tend to write this way *please* be careful to insure that your observations are easy for someone else to decipher). To assist in delineating between visits one and two detections and notations, we suggest you use a different colored ink (red) on the map for your second visit (Appendix B).

Partial (Edge) Territories – Territories that are only partially inside the area search plot need special attention, since they can significantly influence our breeding density estimate. If a territorial bird spends part of its time inside and part of it outside the area search plot, the surveyor needs to delineate the territory as 0.5 or basically ½ a territory. This delineation would also be true for a territorial bird that you may only have detected within the plot, but it was so close to the edge, that its nest could just as easily be in the adjacent habitat outside the plot. Therefore a singing male Black-throated Sparrow noted within, but at the edge of the plot would be coded: "0.5 BTSP-D-M". So for those edge territories where an active nest was never found the surveyor will be responsible at the end of the season for determining if a territory should remain 0.5, dropped completely, or upgraded to 1.0 (full territory) within the plot.

Although many species have territories smaller than a few hectares, habitat can drastically change the average home range of a species based on density and resource availability. Map birds that are singing just off your plot because next time they may be in your plot. Remember, it

is important to spend more time with the edge birds since counting these birds in or out of the plot can bias counts high or low.

Migrants and Non-breeders – For migrants and individuals detected that are determined not to be breeding on the plot (those individuals listed as "I" – Incidental) use the 4-letter species code and list them along the edge of the data form and keep count of individuals. As an example, TOWA III and OSFL I would indicated 3 Townsend's Warblers and 1 Olive-sided Flycatcher were detected while conducting the plot survey (Appendix B).

Completion of Survey 1 – At the completion of the first survey find a nearby shady location (this is a good time for a short rest) and complete the Visit Summary form. This only takes a few minutes but it is essential that you do it in the field while the observations are still fresh in your mind (e.g., you may realize that you forgot to record a bird on the map or an abbreviation may be hard to read). Note that we require the full common name for each species on the summary form (too many errors arise when four-letter codes are used at this stage). As you transfer each observation from the map to the Visit Summary form, you may want to place a small, light check mark next to the observation on the map. This will help you avoid transcription errors but will enable you and others to study the maps (especially after the second survey when you are deciding whether detections of a species on both surveys are of the same or different individuals). As with the maps, *please* print your entries insuring that they are large, not too faint, and legible. On this form, use a separate line for each unique species-zone combination and use hash marks or final tally to indicate the number of records of each observation type (Appendix C). **Please do not use a separate line for each individual observation as this takes too much space.** As an example, for a plot with numerous territorial Black-throated Sparrows within open desert habitat, please include all records for that species on a single line. So for Black-throated Sparrow in desert habitat 'D', your single line entry may include something like one occupied nest, four pairs, and 16 singing males for the entire plot.

For any migrants or birds noted as Incidental (I) within the plot, simply place the total number of individuals detected in the "# in Group" column for each species. Please do not place them in the male, female or unknown columns even when the sex is known.

Completion of Survey 2 – After completion of the second (or last) survey, sit down in the field and prepare a Visit Summary form using the same approach as described for the first survey. However, only record NEW birds or higher confirmation levels of breeding detected during the previous visit (and a 3rd visit for some plots in se. AZ – see below). Thus if you noted a singing male on territory during your first visit, but observed a pair at this same general location during your second visit, then this individual male would be upgraded to a pair. As mentioned before, this process of 'upgrading' your bird detections to the highest level of breeding status possible is an important goal of your surveys. The plot outline maps are used to help decide whether detections on both surveys were of the same bird (e.g., if they were recorded in about the same general location) or not (e.g., if they were recorded in quite different locations).

Completion of Survey 3 – For some upper Sonoran Desert plots in southeastern Arizona which are significantly influenced by late summer monsoon precipitation with subsequent annual/grass growth, a third survey should be conducted between 15 July and 15 August. This is to potentially

detect new desert breeding species which were not nesting (or even present) earlier in the season. These species include Purple Martin, Rufous-winged Sparrow and Varied Bunting. When conditions are favorable, many desert nesting species have the potential of pulling off two to three successful broods through the lengthy breeding season. Therefore during this third visit, detection of these species are not included since the same pair may move and nest locally within or out of the plot with each nesting attempt. So in summary, only new breeding species not detected on the plot earlier in the season are incorporated into the plot's data collection.

Final Summary – After all visits to the plot have been completed, a Final Summary form must be prepared (Appendix D). This form summarizes both surveys (as captured on the Visit Summary forms) documenting your best conclusion as to the species and the number of breeding individuals/pairs of each species within the plot. The estimates include all birds recorded within the plot on the first survey plus any NEW birds or higher confirmation levels of breeding detected during the second (and/or third) visit. Birds recorded on multiple surveys are only included once in the estimate.

At the top of the form, write the plot number, year, and your name (as surveyor). Fill in the Final Summary form as you've done for the Visit summaries, but enter the "highest" evidence of breeding for birds that were seen on both visits. The order of evidence is nest, followed by probable nest, and so on (the columns in the summary form are in order with highest evidence on the left). As noted above, deciding whether two birds seen on different surveys were the same or different individuals will require some judgment, but making this determination is very important. Also note that the totals for some species may be decimals and not whole numbers. If, for example, the only Rock Wren you find is at the edge of plot and you call it "0.5 ROWR-D-M", then on your Final Summary Form your final count of Rock Wrens is 0.5.

Intensive Surveys

A subset of plots selected for rapid surveys is also randomly selected for intensive surveys in which a separate surveyor visits the plot during the same field season, but with an increased number of survey visits. For plots designated as lower Sonoran Desert, intensive surveyors visited each plot six times typically spaced through the breeding season. Due to their presumed higher density and diversity of breeding species, the number of visits increases to eight for upper Sonoran Desert plots.

During intensive area searches, determination of the breeding status of individuals can often be obtained with much greater accuracy than is possible in rapid area searches because of the increased number of visit to the plot regularly over the entire breeding season. Each survey and data collected is basically the same as for rapid area search surveys. However, an increase in visits allows surveyors the opportunity to spend more time observing unknown status individuals in an effort to determine if they are nesting within or out of the plot. By the last visit, the data collected from the six to eight visits is used to determine how many breeding territories were active within the plot during the survey period and which individuals were only visiting, but not nesting within the plot. At the end of all intensive surveys, the number of breeding pairs for each species is determined based on confirmed breeding evidence detected during any visit, or based

on probable or possible breeding evidence collected during three or more consecutive visits to the same territory.

It is important that the rapid and intensive surveyors must not survey the same day and that surveyor don't discuss their findings with each other during the entire survey season. These two efforts must remain independent.

Conducting Le Conte's Thrasher Playback – The reclusive Le Conte's Thrasher, found only in the sparsely vegetated lower Sonoran and Mohave Desert region, typically breeds during the late winter and early spring period. In Arizona it is considered a Species of Greatest Conservation Need (SGCN) and data are needed to document its geographic distribution and to track population trends. To increase detectability of this species, we will use a six-minute call playback survey. This extra playback survey must be conducted at ALL LOWER Sonoran Desert plots from the vegetation points immediately after you have completed the Area Search survey for the entire plot and after EACH of your Area Search visits to each plot. Please study the data sheet and detailed instructions (Appendix E) carefully in advance of your first survey, and please accurately record your data in the appropriate 1-minute block of time on the sheet. The success of our analyses of these extra data depends greatly on your ability and willingness to follow the survey protocol, and on your skillful and accurate recording of field data.

Collecting Habitat Data - The plot map includes four to six point locations at which we would like you to record simple and basic habitat information. The coordinates (using the UTM system, NAD 83, typically Zone 12 or Zone 11 in far-western Arizona) are included on an additional sheet. You can use them with a GPS unit or find the approximate location just using the map. If relying on the GPS unit, when you are about 25 paces from the location start counting down from 25 and when you reach 0 accept that as the location (exact locations are virtually impossible to find using a GPS; this procedure helps you avoid uncertainty about exactly where to record the habitat data). The habitat data are recorded on a separate form with more detailed instructions (Appendix F). The vegetation information only needs to be collected during one of the visits to the plot. We recommend collecting the vegetation an afternoon before one of your two visits or immediately after completing your bird surveys. As a suggestion, we recommend collecting the vegetation data as early in the season as possible since temperatures in the desert quickly climb to uncomfortable levels as the season progresses. Recording the information at a single location should only take a few minutes, especially after you have done the first few locations.

Documenting Raptor Nests– We are also interested in obtaining specific nest site information for several sparsely distributed raptor species that you may encounter on or off your plot(s) while traveling or camping. These include the cliff-nesting raptors; such as the Prairie Falcon, Peregrine Falcon, and Golden Eagle, and Harris's Hawk which typically nests in more vegetated areas of the upper Sonoran Desert. If you discover an active nest, please record the date, the UTM coordinates (NAD 83), and briefly describe what breeding evidence was observed.

Blank Data Forms – Appendix I

Please return all completed summary forms, survey plot maps and vegetation form **by 10 September** to: Troy Corman

Nongame Wildlife Branch
Arizona Game and Fish Department
5000 W. Carefree Hwy.
Phoenix, AZ 85086

Literature Cited

Bart, J., and S. Earnst. 2002. Double-sampling to estimate density and population trends in birds. Auk 119:36-45.

Corman, T.E., and C. Wise-Gervais (editors). 2005. *Arizona Breeding Bird Atlas*. Univ. of New Mexico Press, Albuquerque.

APPENDICES

Appendix A. Sonoran Desert Bird and Plant Abbreviations and Codes.

Four-letter codes for birds

In most cases, the code consists of the first two letters of the first and last names (e.g., BETH = Bendire's Thrasher). When the first name is hyphenated, the first letter of each word is used (e.g., BCFL = Brown-crested Flycatcher). When the last name is hyphenated, the first two letters of the *first* word are used (e.g., WESO = Western Screech-Owl). When two species would have the same code, adjustments are made (e.g., CANW = Canyon Wren; CACW = Cactus Wren). Codes for bird species which regularly breed in Sonoran Desert and dry wash habitats in Arizona are shown below.

Species	Code	Species	Code	Species	Code
Abert's Towhee	**ABTO**	Elf Owl	**ELOW**	Pyrrhuloxia	**PYRR**
American Kestrel	**AMKE**	European Starling	**EUST**	Phainopepla	**PHAI**
Ash-throated Flycatcher	**ATFL**	Ferruginous Pygmy-Owl	**FEPO**	Prairie Falcon	**PRFA**
Barn Owl	**BANO**	Gambel's Quail	**GAQU**	Purple Martin	**PUMA**
Bell's Vireo	**BEVI**	Gila Woodpecker	**GIWO**	Red-tailed Hawk	**RTHA**
Bendire's Thrasher	**BETH**	Gilded Flicker	**GIFL**	Rock Wren	**ROWR**
Black-tailed Gnatcatcher	**BTGN**	Golden Eagle	**GOEA**	Rufous-crowned Sparrow	**RCSP**
Black-throated Sparrow	**BTSP**	Greater Roadrunner	**GRRO**	Rufous-winged Sparrow	**RWSP**
Black Vulture	**BLVU**	Great Horned Owl	**GHOW**	Say's Phoebe	**SAPH**
Bronzed Cowbird	**BRCO**	Harris's Hawk	**HASH**	Scott's Oriole	**SCOR**
Brown-crested Flycatcher	**BCFL**	Hooded Oriole	**HOOR**	Turkey Vulture	**TUVU**
Brown-headed Cowbird	**BHCO**	Horned Lark	**HOLA**	Varied Bunting	**VABU**
Cactus Wren	**CACW**	House Finch	**HOFI**	Verdin	**VERD**
Canyon Towhee	**CANT**	Ladder-backed Woodpecker	**LBWO**	Vermilion Flycatcher	**VEFL**
Canyon Wren	**CANW**	Le Conte's Thrasher	**LCTH**	Violet-green Swallow	**VGSW**
Chihuahuan Raven	**CHRA**	Lesser Nighthawk	**LENI**	Western Kingbird	**WEKI**
Common Poorwill	**COPO**	Loggerhead Shrike	**LOSH**	Western Meadowlark	**WEME**
Common Raven	**CORA**	Long-eared Owl	**LEOW**	Western Screech-Owl	**WESO**
Costa's Hummingbird	**COHU**	Lucy's Warbler	**LUWA**	White-throated Swift	**WTSW**
Crested Caracara	**CRCA**	Mourning Dove	**MODO**	White-winged Dove	**WWDO**
Crissal Thrasher	**CRTH**	Northern Cardinal	**NOCA**	Zone-tailed Hawk	**ZTHA**
Curve-billed Thrasher	**CBTH**	Northern Mockingbird	**NOMO**		

Four-letter codes for plants

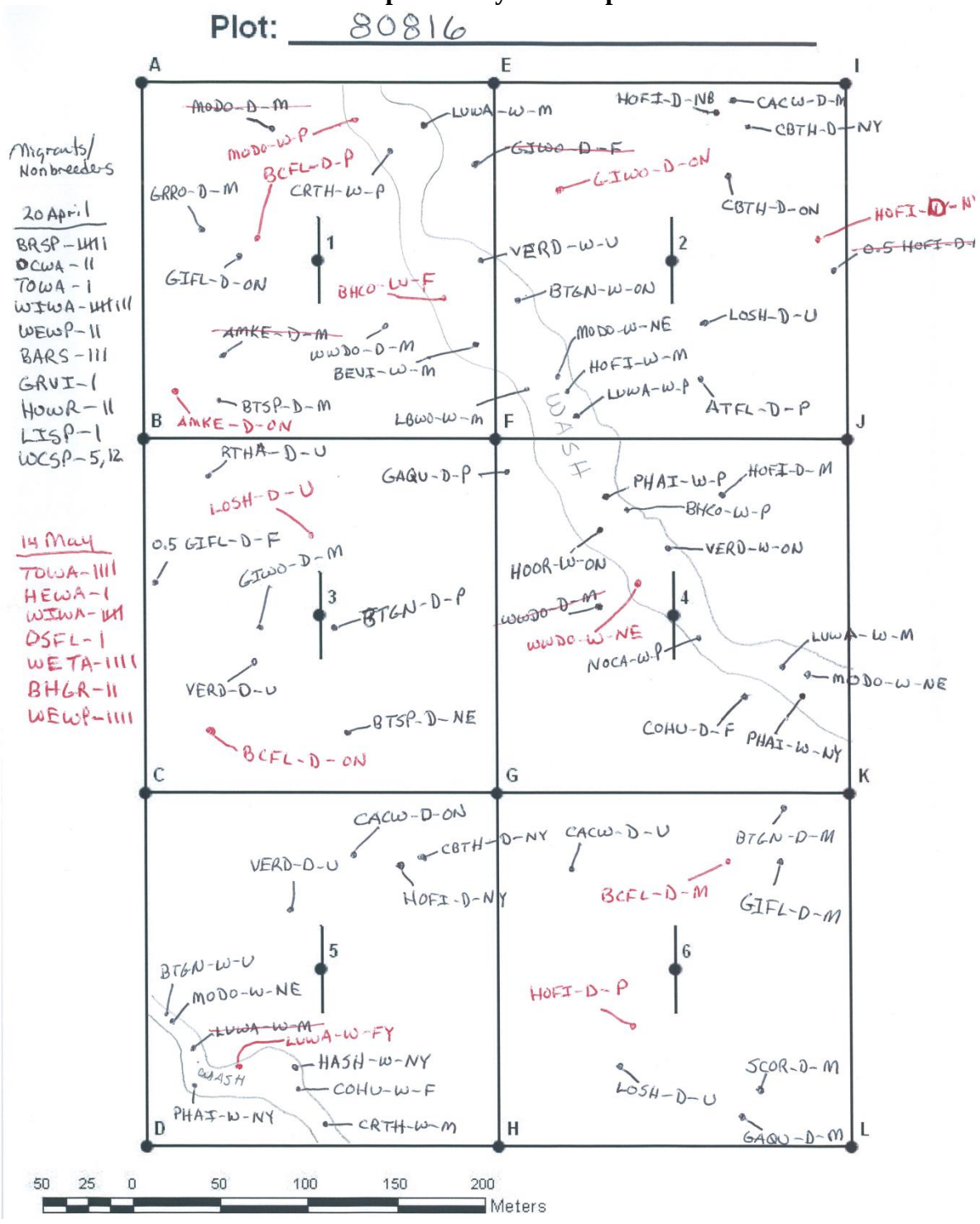
Codes for trees and woody plants commonly found in Sonoran Desert and associated dry washes are shown below.

Common Name	CODE	Scientific Name
acacia, catclaw	**ACCA**	*Acacia greggii*
acacia, whitethorn	**ACWH**	*Acacia constricta*
barberry, spp.	**BARB**	*Berberis*, spp.
barrel cactus, spp.	**BACA**	*Ferocactus* spp.
brittlebush	**BRIT**	*Encelia farinosa*
buckwheat, flattop	**BUFT**	*Eriogonum, fasciculatum*
bursage, white	**BUWH**	*Ambrosia dumosa*
bursage, triangle-leaf	**BUTR**	*Ambrosia deltoidea*
burrobrush	**BURR**	*Hymenoclea salsola*
canyon ragweed	**CARA**	*Ambrosia ambrosioides*
cholla, buckhorn	**CHBU**	*Cylindropuntia acanthocarpa*
cholla, cane	**CHCA**	*Cylindropuntia spinosior*
cholla, chain-fruit	**CHCH**	*Cylindropuntia fulgida*
cholla, Christmas	**CHCH**	*Cylindropuntia leptocaulis*
cholla, pencil	**CHPE**	*Cylindropuntia arbuscula*
cholla, staghorn	**CHST**	*Cylindropuntia versicolor*
cholla, teddybear	**CHTE**	*Cylindropuntia bigelovii*
cholla, walkingstick	**CHWA**	*Cylindropuntia spinosior*
cholla, whipple	**CHWH**	*Cylindropuntia whipplei*
chuparosa	**CHUP**	*Justicia californica*
creosotebush	**CREO**	*Larrea tridentata*
crucifixion thorn	**CRTH**	*Canotia holacantha*
desert broom	**DEBR**	*Baccharis sarothroides*
desert lavender	**DELA**	*Hyptis emoryi*
desert rosemary	**DERO**	*Poliomintha incana*
desert senna	**DESE**	*Senna covesii*
desert willow	**DEWI**	*Chilospsis linearis*
Ephedra (Mormon tea)	**EPHE**	*Ephedra* spp.
elephant tree	**ELTR**	*Bursera microphylla*
fairyduster	**FAIR**	*Calliandria eriophylla*
globemallow, spp.	**GLOB**	*Sphaeralcea* spp.
graythorn	**GRAY**	*Ziziphus obtusifolia*
hackberry, desert	**HADE**	*Celtis pallida*
hackberry, netleaf	**HANE**	*Celtis laevigata var. reticulata*
hopbush	**HOPB**	*Dodonaea viscosa*
ironwood	**IRON**	*Olneya tesota*
jojoba	**JOJO**	*Simmondsia chinensis*
joshua tree	**JOTR**	*Yucca brevifolia*
juniper, spp.	**JUNI**	*Juniperus* spp.
mesquite, honey	**MEHO**	*Prosopis glandulosa*
mesquite, velvet	**MEVE**	*Prosopis velutina*
mimosa, spp.	**MIMO**	*Mimosa* spp.
oak, scrub live	**OASC**	*Quercus turbinella*
ocotillo	**OCOT**	*Fouquieria splendens*

paloverde, blue	**PABL**	*Parkinsonia florida*
paloverde, foothill	**PAFO**	*Parkinsonia microphylla*
prickly pear, spp.	**PRPE**	*Opuntia* spp.
ratany spp.	**RATA**	*Krameria spp*
ratany, white	**RAWH**	*Krameria grayi*
ratany, range (littleleaf)	**RARA**	*Krameria erecta*
saguaro	**SAGU**	*Carnegiea gigantea*
saltbush, four-winged	**SAFO**	*Atriplex canescens*
saltbush, littleleaf	**SALI**	*Atriplex polycarpa*
sugar sumac (sugar bush)	**SUMA**	*Rhus ovata*
tamarisk spp. (salt cedar)	**TAMA**	*Tamarix* spp.
Trixis	**TRIX**	*Trixis califonica*
turpentine brush	**TUBU**	*Ericameria laricifolia*
wolfberry, spp.	**WOLF**	*Lycium* spp.
unknown cholla	**UNCH**	
unknown shrub	**UNSH**	
unknown tree	**UNTR**	

Appendix B. Example of a completed Rapid Survey Plot Map form.

Arizona Coordinated Bird Monitoring Program
Rapid Survey Plot Map



Appendix C. Example of a completed Sonoran Desert Bird Survey Visit Summary form.

Rapid Survey

AZCBM- Sonoran Desert Bird Survey
Visit Summary

Page 1 of 2

Plot number: 80816 Date: 20 April 2012 Surveyor: Seymore Byrds

Visit # (check): 1 [X] 2 [ ] 3 [ ]

TIME-- Start: 0550 End: 1035 TEMP-- Start: 53 End: 81
% Cloud Cover: 10 Wind: 1 Precipitation: 0

Comments:

Species	Zone	Occup. Nest	Prob. Nest	Pair	Male	Female	Unk. sex	# in Group
Mourning Dove	D				1			
Mourning Dove	W	3						
Crissal Thrasher	W			1	1			
Lucy's Warbler	W			1	3			
Verdin	W	1					1	
Verdin	D						2	
Gilded Flicker	D	1			1	0.5		
Black-tailed Gnatcatcher	W	1					1	
Black-tailed Gnatcatcher	D			1	1			
White-winged Dove	D				2			
Black-throated Sparrow	D	1			1			
Gila Woodpecker	D				1	1		
House Finch	D	2			1.5			
House Finch	W				1			
Cactus Wren	D	1			1		1	
Curve-billed Thrasher	D	3						
Loggerhead Shrike	D						2	
Red-tailed Hawk	D						1	
Gambel's Quail	D			1	1			
Phainopepla	W	2		1				
Brewer's Sparrow	I							6
Orange-crowned Warbler	I							2
Townsend's Warbler	I							1
Gray Vireo	I							1
Wilson's Warbler	I							8

Please record dates using the format 23 Apr 2012.

Record cloud cover as percent of the sky covered by clouds.

Precipitation codes are brief/steady and light/medium (i.e., brief light).

Codes for zones are D=desert, W=wash, I=incidental (not breeding on plot).

Use the ON=occupied nest only if the nest was seen or other confirmed nesting behavior observed.

Record wind using the Beaufort Scale: **0** = Smoke rises vertically (<1 mph), **1** = Wind direction shown by smoke drift (1-3 mph), **2** = Wind felt on face; leaves rustle (4-7 mph), **3** = Leaves, small twigs in constant motion (8-12 mph), **4** = Dust rises; small branches move (13-18 mph), **5** = Small trees in leaf begin to sway (19-24 mph)

Appendix D. Example of a completed Sonoran Desert Bird Rapid Survey Final Summary Form.

Rapid Survey

AZCBM- Sonoran Desert Bird Survey
***Final Summary**

Page 1 of 2

Plot number: 80816 Year: 2012 Surveyor: Seymore Byrds

Species	Zone	Occup. Nest	Prob. Nest	Pair	Male	Female	Unk. sex	# in Group
Mourning Dove	W	3		1				
Crissal Thrasher	W			1	1			
Lucy's Warbler	W	1		1	2			
Verdin	W	1					1	
Verdin	D						2	
Gilded Flicker	D	1			1	0.5		
Black-tailed Gnatcatcher	W	1					1	
Black-tailed Gnatcatcher	D			1	1			
White-winged Dove	D				1			
White-winged Dove	W	1						
Black-throated Sparrow	D	1			1			
Gila Woodpecker	D	1			1			
House Finch	D	3		1	1			
House Finch	W				1			
Cactus Wren	D	1			1		1	
Curve-billed Thrasher	D	3						
Loggerhead Shrike	D						3	
Red-tailed Hawk	D						1	
Brown-crested Flycatcher	D			1	1			
Gambel's Quail	D			1	1			
Phainopepla	W	2		1				
American Kestrel	D	1						
Brown-headed Cowbird	W			1		1		
Hooded Oriole	W	1						
Harris's Hawk	W	1						
Ash-throated Flycatcher	D			1				
Brewer's Sparrow	I							6
Townsend's Warbler	I							5
Gray Vireo	I							1
Wilson's Warbler	I							13
Olive-sided Flycatcher	I							1
Western Tanager	I							4
Western Wood-Pewee	I							4
Barn Swallow	I							3

*Summarize all survey visits documenting your best determination as to the species and the number of breeding individuals/pairs of each species within the plot.

Appendix E. Le Conte's Thrasher Survey Instructions and Completed Data Form Example

FIELD INSTRUCTIONS FOR LE CONTE'S THRASHER SURVEYS
John Arnett, Troy Corman

In advance of the survey day, please familiarize yourself with the measurement methods.

To begin:

1. Record the **Date**, **Plot Number** and name of **Observer(s)** on top of the form.
2. Record **Weather** an **Environmental Data**. (The methods to measure Sky, Wind (Beaufort scale), and Noise are described at the bottom of the data sheet.)
3. Record the **Station #** (the plot number followed by the vegetation sampling point number, for example: 17283-01.)
4. Play the six-minute audio recording once at each of the six vegetation sampling points of your plot. Record the **Start Time** at the start of each playback**.**

The recording begins with a voice (courtesy of Pierre Deviche) that announces "One" followed by one minute of silence (minute 0-1); this is **Pass #1**. Next is **Pass #2**, with one minute of silence (minute 1-2). Next is **Pass #3**, which includes about 45 seconds of a LCTH song (minute 2-3). Next is **Pass #4** with a one minute of silence (minute 3-4). Next is **Pass #5**, which includes about 45 seconds of a LCTH song (minute 4-5). Next is **Pass #6** (minute 5-6). The survey concludes when the recording announces "End." The volume of the playback should be loud enough to broadcast approximately 200 m, but not so loud that the song is distorted.

For each LCTH you detect during the survey, record "LCTH" in the **Species** column. Each individual bird gets its own row on the data sheet. In the column for each of the 6 **Passes**, write an 'S' for a seen bird, a '1' for a heard bird, and '1S' for a bird heard and seen. These directions are printed at the top of the data sheet, just above the table.

The specific vocalization(s) heard for any LCTH should be noted in the column **LCTH Vocal Type(s)**. Please write '1' for the typical male song, '2' for the "drip" call, or '3' for Other. Please accurately describe any 'Other' vocalizations in the form's comments section; it may be a vocalization we are not familiar with or is not described in the literature.

During your call-playback, be alert for a thrasher coming from the direction of your previous point. If you detect a LCTH that followed you from a previous survey point, please write "Y" in the "**Detected at a previous point**" column. Write "N" for a thrasher you had not previously detected.

Please note that you may detect a thrasher AFTER you have completed the six-minute survey. If this happens, please record on the data sheet that this thrasher was detected **Outside the Survey Period**. Do not include it as a bird detected during the official six-minute survey.

During and following the playback be alert all around you for silent thrashers running toward you or perched atop a distant shrub or small tree. If you detect a thrasher during the six-minute

survey, please keep track of the bird while you complete the survey. Always play the full six minute recording. At the end of the recording, if you still know where the thrasher is located, quietly and stealthily follow the bird to evaluate whether it's breeding within the plot (see *Noting Species Detections on Area Search Plot Map* section below) then proceed to your next survey point and resume your playback surveys.

Other Thrasher Species

During the six-minute survey, you may detect a thrasher but you cannot identify it to species. Be advised that other thrasher species may respond to the LCTH playback, and some of their vocalizations may sound similar to the LCTH song. AFTER the conclusion of the six-minute survey, you may follow the unidentified thrasher to identify it. All thrashers other than LCTH should be noted on the Area Search Plot Map, and NOT on the LCTH Survey Form.

Noting Species Detections on Area Search Plot Map

If you detect a Le Conte's Thrasher during the six-minute survey, please note the location of the bird on the plot map with the code series beginning with "PB" (playback). Therefore the code series for a Le Conte's Thrasher 'LCTH' of unknown sex 'U' detected in desert habitat 'D' would look like "PB-LCTH-D-U". If you detect a single individual on a perch, check on the ground or in an adjacent shrub for another thrasher. As with the rest of your Area Search, it is important to determine if a single thrasher is actually part of a breeding pair whose territory is wholly or partially within your plot. Also, try to determine if the bird(s) was already in the plot, or if it entered into your plot in response to the playback. Thrashers may follow you from one point to the next.

During each LCTH six-minute survey period the focus is obviously on detecting any LCTHs, however if you observe any other birds that may be breeding in the plot (and that have not already been marked on the Area Search map) evaluate their breeding status and properly record them on the Area Search plot map. Mapping of any other birds should be done only after the six-minute survey period has been completed.

Field Prep

Practice the playback protocol, study the data sheet, make sure you understand how the six-minute recording, with six survey periods, corresponds with the LCTH data sheet. Your speaker(s) must broadcast the thrasher recording loudly and clearly with minimal sound distortion. You will need to load the six-minute file into a playback device (e.g., iPod, smartphone, or mp3 player). Please have plenty of batteries for your playback device and speaker(s).

The playback file can be obtained at the Bird Sounds Library at the Arizona Field Ornithologists website (www.azfo.org) or by emailing Troy Corman (tcorman@azgfd.gov) or Edwin Juarez (ejuarez@azgfd.gov).

Completed LCTH Data Form Example

Lower Sonoran Desert Bird Monitoring - Le Conte's Thrasher Survey Pg_1__of__2__

Date *(eg 3-Dec-12)*: **17-MAR-2012** **Observer(s)** *(list all)**: **Scooter Magruder**

Plot Number: 17283

In the "Pass" columns, put an "S" in the appropriate column if the bird was seen, a "1" if the bird was heard, and "1S" if both heard and seen

Station#	Temp C or F	Sky	Wind	Noise	Start Time (military)	Species	Responded During							LCTH Vocal Type(s)	Detected at a Previous Point	Was LCTH in plot before responding? Other comments?
							Pass 1 (0-1)	Pass 2 (1-2)	Pass 3 (2-3)	Pass 4 (3-4)	Pass 5 (4-5)	Pass 6 (5-6)	Outside survey period			
17283 - 01	18 C	1	1	0	955	LCTH	0	0	0	1	1S	1S		1	N	yes
17283 - 02	18	1	1	1	1021	LCTH	1	1	0	0	0	1		2	N	yes
17283 - 03	19	1	1	0	1039	none										
17283 - 04	19	1	1	0	1058	LCTH	0	0	0	0	0	1		1	Y	previously detected at 17283-04
17283 - 05	19	1	1	0	1122	none										
17283 - 06	20	1	0	1	1144	LCTH	0	0	0	S	S	S			N	No, this pair came in
							0	0	0	S	1S	1S		1		from outside the plot

Sky: 0 *clear or a few clouds* 1 *partly cloud or variable sky* 2 *cloudy or overcast* 4 *fog or smoke* 5 *drizzle* 6 *snow* 8 *showers*

Wind (Beaufort) scale: 0 *smoke rises vertically* 1 *wind direction shown by smoke drift* 2 *wind felt on face; leaves rustle* 3 *leaves , small twigs in constant motion; light flag extended* 4 *raises dust and loose paper; small branches are moved* 5 *small trees with leaves sway; crested wavelets on inland waters*

Noise: 0 *no noise* 1 *faint noise* 2 *moderate noise (probably can't hear some birds beyond 100m)*

3 *loud noise (probably can't hear some birds beyond 50m)* 4 *intense noise (probably can't hear some birds beyond 25m)*

LCTH Vocal Types: 1 typical male song 2 "drip" call 3 Other (please describe)

Appendix F. Sonoran Desert Habitat Evaluation.

In Arizona, Sonoran Desert habitats fall into three basic categories:

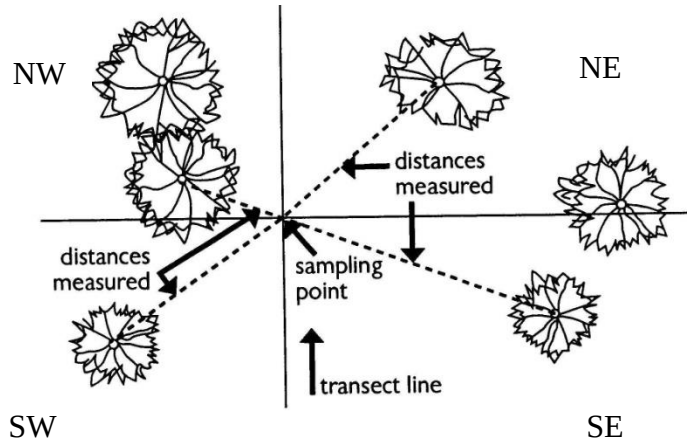
Habitat/Elevation (ft)	Common Sonoran Desert Trees, Shrubs and Cacti
Lower Sonoran/ <1800	Creosotebush, triangleleaf bursage, white bursage, brittlebush, cholla, mesquite, foothill paloverde, wolfberry, littleleaf saltbush
Upper Sonoran/ 1200 - 3600	Saguaro, cholla, barrel cactus, prickly pear, blue and foothill paloverde, velvet mesquite, ironwood, creosotebush, ocotillo, jojoba, brittlebush, triangleleaf bursage, wolfberry
Dry Wash/ 100 – 3600	Ironwood, blue paloverde, velvet mesquite, catclaw acacia, desert hackberry, desert willow, desert broom, saltbush, creosotebush, canyon ragweed, graythorn

The dominant plant species, diversity of plant species, density and abundance of vegetation, plus the structure (age/height) of the vegetation often dictate the diversity and density of the breeding birds within an area. In an effort to begin to address this important relationship, each plot includes four (upper Sonoran) or six (lower Sonoran) sets of UTM coordinates designating locations at which we need basic information on the vegetation. Using your GPS unit, find these points and write the UTM coordinates (NAD83) on the Habitat Evaluation Form. Also include the average elevation (in meters) among the plot vegetation points and by using the satellite imagery plot map estimate the percentage of the plot which includes wash vegetation.

Point-Center Quarter: Each vegetation point represents the center of the measurement area. From the center point, use a compass or GPS to define the four quadrants or QUARTERS (NORTHEAST, SOUTHEAST, SOUTHWEST and NORTHWEST).

Note:

- In each of these quarters, identify and measure the distance (in 0.1 meter increments) to the closest woody plant from the center point. Please measure to the main trunk (for single-stemmed trees) or to the center of a multi-stemmed tree or shrub.
- If unable to reach the UTM point designated due to safety issues, you may randomly choose a point within the same quadrant. Please note, if this is necessary it is also important to evaluate if you are able to completely survey birds within that quadrant.
- For distant plants use a laser rangefinder or pace out the distance and record in one-meter increments. It is critical to obtain accurate distance measurements to plants because accurate plant density estimates are dependent upon it. This manual includes a list of common Sonoran Desert plants and their 4-letter code (Appendix A) to use when completing the Habitat Evaluation Form.



Cholla Density: estimate density of cholla cacti. *For each QUARTER within 100 m of vegetation point*, estimate number of individual cholla plants that are >0.5 m in height. *Please note there is no need to identify the cholla to species*. Also disregard small stature species such as pencil cholla (*Cylindropuntia arbuscula*). Place the most appropriate density designation for each quarter using the following category range:

0 (no cholla), Low (<5 plants), Medium (5-25 plants), and High (>25 plants)

Woody Desert Plant Density and Structure: describes the density, diversity and vertical complexity of the vegetation. *For each QUARTER within 100 m of vegetation point* measure distance to nearest woody shrub or tree in the following three vertical structure categories: <0.5 m, 0.5-3 m, and >3 m. *Please note in the first categories (<0.5 m), there is no need to identify the woody shrub to species.* However, do include the plant species code for the taller shrub/tree categories (0.5-3 m and > 3 m) (Appendix A).

Mistletoe Density: estimate density of mistletoe clumps. W*ithin a 100 m radius (360°) of vegetation point*, use binoculars (if necessary) to estimate number of mistletoe clumps. Place the most appropriate density designation using the following category range:

0 (no mistletoe), Low (<10 clumps), Medium (10-50 clumps), and High (>50 clumps)

Saguaro Density: estimates density and basic age-class of saguaros. From the sampling point, use binoculars and laser rangefinder (if necessary) to count the number of saguaros within a *100 m radius (360°)* and place them into two categories: with arms and without arms.

Grass/Forbs Ground Cover: describes the amount of ground covered by non-woody plants (grasses and forbs). Along a 50 m line in the North direction only from the vegetation point, estimate the number of meters along this line that intersect with "native" grass/forb ground cover (live/dead). Please note this "native" grouping includes some common low-growing exotic forbs not listed below. Also estimate the number of meters along this line that intersect with one or more of the following seven invasive plant species. To assist in proper identification of these species, images of them can be found in Appendix H:

Sahara mustard (*Brassica tournefortii*)
Red brome (*Bromus rubens var. madritensis*)
Buffelgrass (*Cenchrus ciliaris* or *Pennisetum ciliare*)
Arabian or Mediterranean grass (*Schismus arabicus*)

Bermuda grass (*Cynodon dactylon*)
Fountain grass (*Pennisetum setaceum*)
Russian thistle (*Salsola iberica*)

Physical Attributes and Invasive Plants presence: documents various physical attributes of the plot, plus the distribution of several invasive plant species which potentially threaten Sonoran Desert habitats. For the *entire plot*, please place an "X" on the line to the right of any of the listed physical attributes noted and invasive plant species you detected. Please see above for list of invasive plant species and Appendix 8 for images of each.

Appendix G. Example of a completed Sonoran Desert Plot Habitat Evaluation Form.

Arizona Coordinated Bird Monitoring — *Arizona Bird Conservation Initiative*

Plot# 1032

Sonoran Desert Plot Habitat Evaluation Form

Date: 5 March 2013

Plot Vegetation Points (4 points on Upper Sonoran plots or 6 points on Lower Sonoran plots)

Point-Centered Quarter: within each quarter and within a **100 m** of vegetation point, measure distance to nearest plant in each height category. Write species codes for plants >0.5 m only. *Do not identify cholla or shrubs <0.5m*. For **cholla** use **0 (none), L (<5), M (5-25), or H (>25)**

Surveyor(s): Seymore Byrds

Average Elevation (m): 622

% of Plot is Wash (use imagery): 15

	1	2	3	4	5	6
Northeast (identify species of shrubs/trees over >0.5 m & record distance)						
Cholla sp. (>0.5m)	H	M	0	L	0	L
Shrub sp. (≤0.5m)	5.2	3.4	2.8	0.8	3.5	4.1
Shrub/tree(>0.5 to 3m)	CREO 8.2	CREO 1.4	GRAY 12.2	ACCA 8.1	CREO 16.4	CREO 23.1
Tree (>3 m)	—	—	—	—	MEVE 29	MEVE 62
Southeast (identify species of shrubs/trees over >0.5 m & record distance)						
Cholla sp. (>0.5m)	0	0	L	M	M	0
Shrub sp. (≤0.5m)	0.8	3.1	2.2	6.8	10	1.2
Shrub/tree(>0.5 to 3m)	CREO 18.5	ACCA 23	CREO 8.8	CREO 42	—	CREO 14
Tree (>3 m)	MEVE 8.3	PABL 38	PABL 89	—	—	MEVE 16
Southwest (identify species of shrubs/trees over >0.5 m & record distance)						
Cholla sp. (>0.5m)	L	0	0	0	L	M
Shrub sp. (≤0.5m)	0.9	0.5	6.2	3.8	22.6	31.2
Shrub/tree(>0.5 to 3m)	HADE 28	—	CREO 10.5	CREO 5.8	CREO 19.4	CREO 22
Tree (>3 m)	PABL 68	IRON 82	—	IRON 58.2	MEVE 30	MEVE 10
Northwest (identify species of shrubs/trees over >0.5 m & record distance)						
Cholla sp. (>0.5m)	L	H	0	M	0	0
Shrub sp. (≤0.5m)	11.2	0.2	16.8	24.8	9.1	1.2
Shrub/tree(>0.5 to 3m)	—	CREO 15.6	—	CREO 17	HADE 53	—
Tree (>3 m)	PAFO 77	—	PAFO 5.6	—	IRON 63	IRON 92

UTM, NAD83

1	331019 mE	3544110 mN
2	331219 mE	3544110 mN
3	331019 mE	3544310 mN
4	331219 mE	3544310 mN
5	331019 mE	3544510 mN
6	331219 mE	3544510 mN

WITHIN ENTIRE PLOT:

Place an X to indicate presence:

Vertical cliff >100' high	
Tank w/ standing water	X
Burned habitat (any evidence)	
OHV use evidence ≤ 1 year	
Livestock evidence ≤ 1 year	X
Other (describe)	

Invasive Plants

Sahara mustard	X
Red brome	X
Buffelgrass	
Arabian Mediterranean grass	
Bermuda grass	
Fountain grass	
Russian thistle	

Mistletoe (estimate # of mistletoe clumps within a **100 m** radius of veg. point: 360°)

Category (Low, Medium, or High): Use **0 (none), L (<10), M (10-50), H (>50)**

Mistletoe clumps:	L	H	H	0	L	M

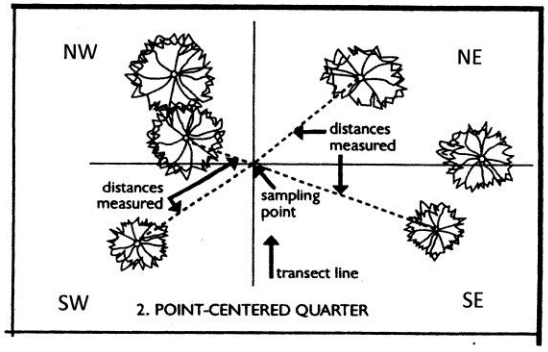
Saguaro Count (while standing at veg. pt., count all saguaros within a **100 m** radius; 360°)

Armed	10	6	4	7	2	3
Unarmed	—	1	—	3	—	3

Grass/forb ground cover (live/dead) (at veg. pt. along **50 m** line in North direction)

# of meters "native"	21	8	5	2	8	10
# of meters invasive	4	2	—	1	—	—

NOTES:



2. POINT-CENTERED QUARTER

Appendix H. Photos of Sonoran Desert Invasive Plant Species.

Sahara Mustard *Brassica tournefortii*

All above: http://cabezaprieta.org by Hank Jorgensen

Buffelgrass *Pennisetum ciliare* or *Cenchrus ciliaris*

http://www.buffelgrass.org by Christine Hannum

www.tropicalforages.info/key/Forages/Media/Html/ by Chris Gardiner

Larry Allain @ USDA-NRCS PLANTS Database

Fountain grass ***Pennisetum setaceum***

Both above: http://cabezaprieta.org By Hank Jorgensen

Red Brome ***Bromus rubens var. madritensis***

Patrick J. Alexander @ USDA-NRCS PLANTS Database


www.blm.gov/pgdata Stephen Laymon


www.arizonensis.org Michael J. Plagens 2008

Arabian or Mediterranean Grass ***Schismus arabicus***

Dale A. Zimmerman Herbarium, Western New Mexico University

CalPhotos.berkeley.edu © Steve Matson 2011

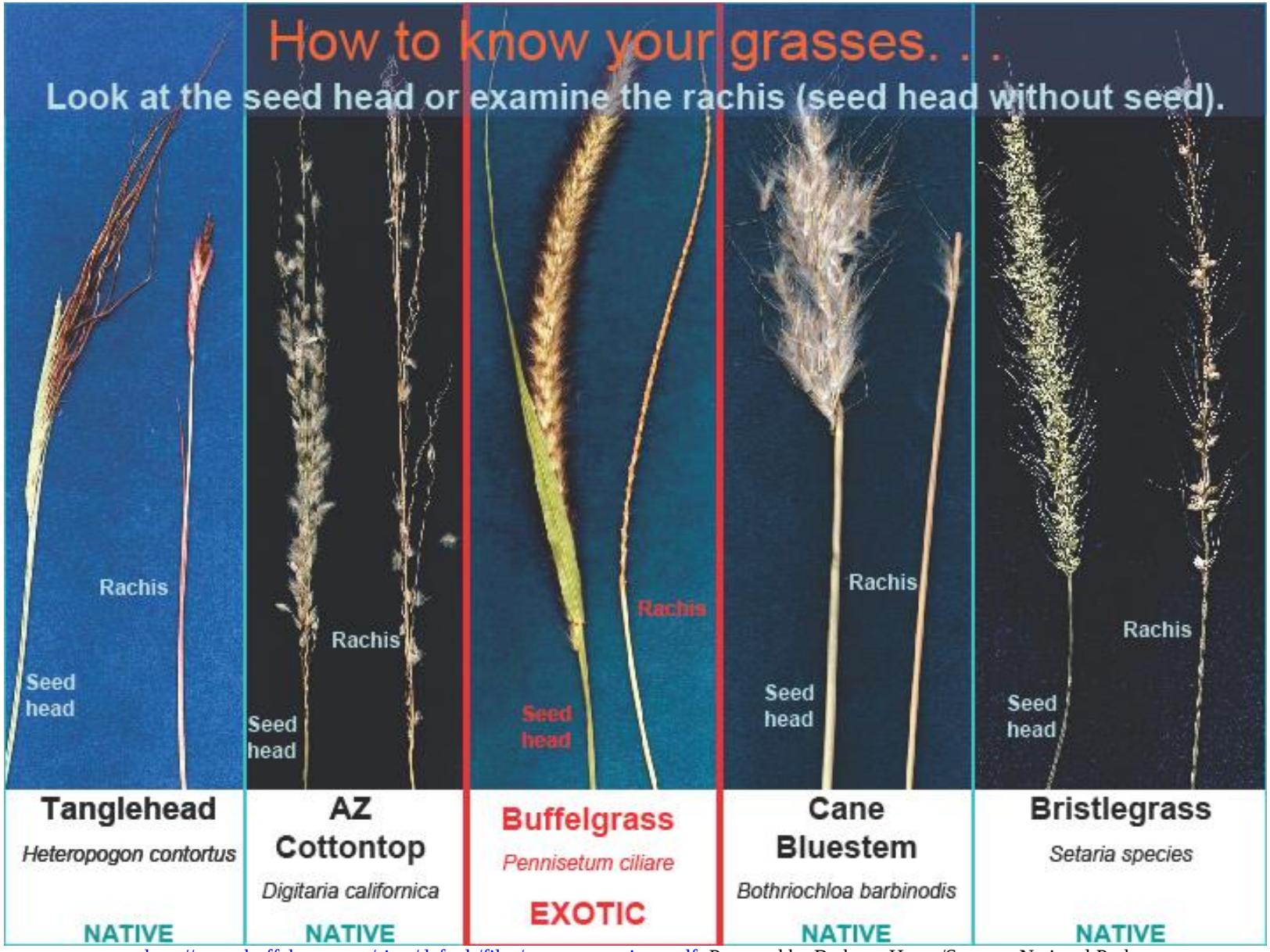
CalPhotos.berkeley.edu © Joe DiTomaso 2001

Bermuda Grass ***Cynodon dactylon***

Both above: http://www.saguaro-juniper.com/i_and_i/invasive_spp/bermuda_grass.html

Russian thistle (tumbleweed) ***Salsola tragus* or *iberica***

Both above: www.delange.org/ThistleRussian
Images Copyright George & Audrey DeLange



http://www.buffelgrass.org/sites/default/files/grasscomparison.pdf; Prepared by Bethany Hontz/Saguaro National Park

Appendix I. Blank Data Forms

Rapid Survey

AZCBM- Sonoran Desert Bird Survey
Visit Summary

Plot number: _____ Date: _____ Surveyor: _____

Visit # (check) 1 ☐ 2 ☐ 3 ☐

TIME-- Start: _____ End: _____ TEMP-- Start: _____ End: _____

% Cloud Cover: _____ Wind: _____ Precipitation: _____

Comments: _____

Species	Zone	Occup. Nest	Prob. Nest	Pair	Male	Female	Unk. sex	# in Group

Please record dates using the format 23 Apr 2012.

Record cloud cover as percent of the sky covered by clouds.

Precipitation codes are brief/steady and light/medium (i.e., brief light).

Codes for zones are D=desert, W=wash, I=incidental (not breeding on plot).

Use the ON=occupied nest only if the nest was seen or other confirmed nesting behavior observed.

Record wind using the Beaufort Scale: **0** = Smoke rises vertically (<1 mph), **1** = Wind direction shown by smoke drift (1-3 mph), **2** = Wind felt on face; leaves rustle (4-7 mph), **3** = Leaves, small twigs in constant motion (8-12 mph), **4** = Dust rises; small branches move (13-18 mph), **5** = Small trees in leaf begin to sway (19-24 mph)

Rapid Survey

AZCBM- Sonoran Desert Bird Survey
Visit Summary (continuation page)

Page____of_____

Plot number:

Species	Zone	Occup. Nest	Prob. Nest	Pair	Male	Female	Unk. sex	# in Group

Rapid Survey

AZCBM- Sonoran Desert Bird Survey

***Final Summary**

Plot number: _____ Year: _____ Surveyor: _____

Species	Zone	Occup. Nest	Prob. Nest	Pair	Male	Female	Unk. sex	# in Group

*Summarize all survey visits documenting your best determination as to the species and the number of breeding individuals/pairs of each species within the plot.

Intensive Survey

AZCBM- Sonoran Desert Bird Survey
Visit Summary

Plot number: _____ Date: _____ Surveyor: _____

Visit # (check) 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐

TIME-- Start: _____ End: _____ TEMP-- Start: _____ End: _____

% Cloud Cover: _____ Wind: _____ Precipitation: _____

Comments: _____

Species	Zone	Occup. Nest	Prob. Nest	Pair	Male	Female	Unk. sex	# in Group

Please record dates using the format 23 Apr 2012.

Record cloud cover as percent of the sky covered by clouds.

Precipitation codes are brief/steady and light/medium (i.e., brief light).

Codes for zones are D=desert, W=wash, I=incidental (not breeding on plot).

Use the ON=occupied nest only if the nest was seen or other confirmed nesting behavior observed.

Record wind using the Beaufort Scale: **0** = Smoke rises vertically (<1 mph), **1** = Wind direction shown by smoke drift (1-3 mph), **2** = Wind felt on face; leaves rustle (4-7 mph), **3** = Leaves, small twigs in constant motion (8-12 mph), **4** = Dust rises; small branches move (13-18 mph), **5** = Small trees in leaf begin to sway (19-24 mph)

Intensive Survey

AZCBM- Sonoran Desert Bird Survey
Visit Summary (continuation page)

Page____of_____

Plot number:

Species	Zone	Occup. Nest	Prob. Nest	Pair	Male	Female	Unk. sex	# in Group

Intensive Survey

AZCBM- Sonoran Desert Bird Survey

***Final Summary**

Plot number: _____ Year: _____ Surveyor: _____

Species	Zone	Occup. Nest	Prob. Nest	Pair	Male	Female	Unk. sex	# in Group

*Summarize all survey visits documenting your best determination as to the species and the number of breeding individuals/pairs of each species within the plot.

Intensive Survey

AZCBM- Sonoran Desert Bird Survey

<u>*Final Summary (continuation page)</u>

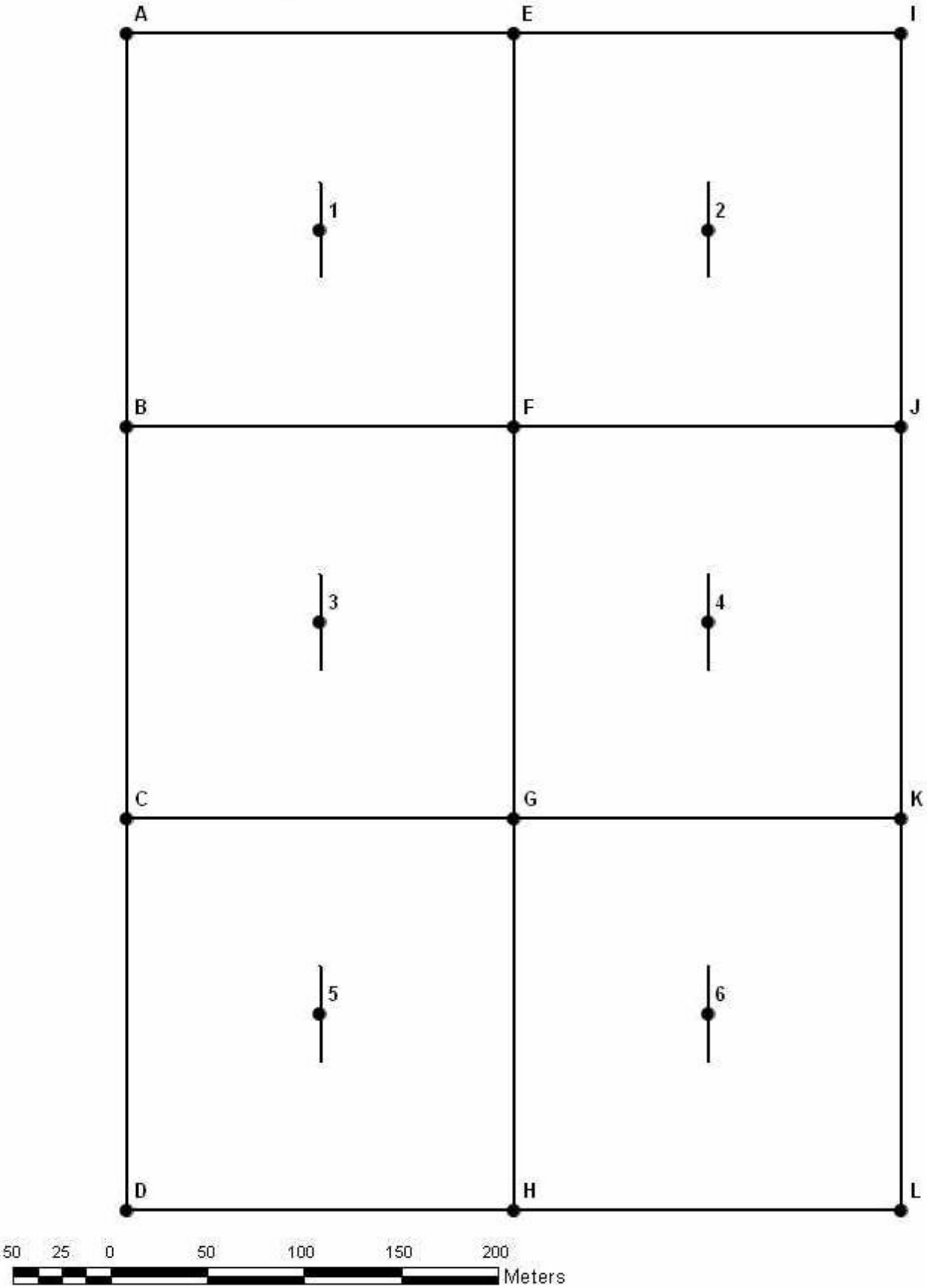
Page______of______

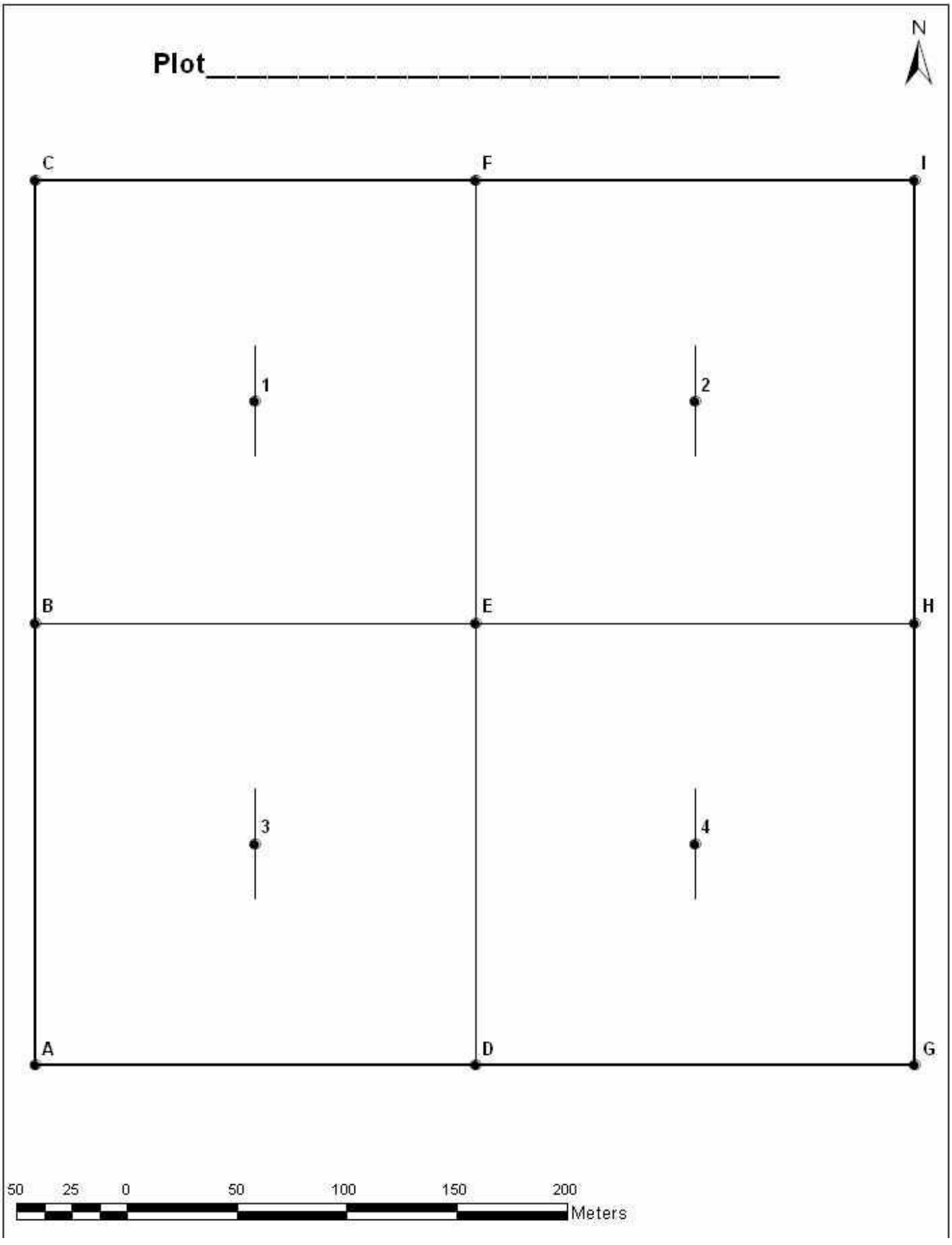
Plot number:

Species	Zone	Occup. Nest	Prob. Nest	Pair	Male	Female	Unk. sex	# in Group

*Summarize all survey visits documenting your best guess as to the species and the number of breeding individuals/pairs of each species within the plot.

Plot: _____




Plot_____
N
C
F
I
1
2
B
E
H
3
4
A
D
G
50 25 0 50 100 150 200
Meters

Arizona Coordinated Bird Monitoring — *Arizona Bird Conservation Initiative*

Plot# _____

Sonoran Desert Plot Habitat Evaluation Form

Date: _____

Plot Vegetation Points (4 points on Upper Sonoran plots or 6 points on Lower Sonoran plots)

Point-Centered Quarter: within each quarter and within a 100 m of vegetation point, measure distance to nearest plant in each height category. Write species codes for plants >0.5 m only.
Do not identify cholla or shrubs <0.5m. For **cholla** use **0 (none), L (<5), M (5-25), or H (>25)**

Surveyor(s): _____
Average Elevation (m): _____
% of Plot is Wash (use imagery): _____

	1	2	3	4	5	6
Northeast (identify species of shrubs/trees over >0.5 m & record distance)						
Cholla sp. (>0.5m)						
Shrub sp. (≤0.5m)						
Shrub/tree(>0.5 to 3m)						
Tree (>3 m)						
Southeast (identify species of shrubs/trees over >0.5 m & record distance)						
Cholla sp. (>0.5m)						
Shrub sp. (≤0.5m)						
Shrub/tree(>0.5 to 3m)						
Tree (>3 m)						
Southwest (identify species of shrubs/trees over >0.5 m & record distance)						
Cholla sp. (>0.5m)						
Shrub sp. (≤0.5m)						
Shrub/tree(>0.5 to 3m)						
Tree (>3 m)						
Northwest (identify species of shrubs/trees over >0.5 m & record distance)						
Cholla sp. (>0.5m)						
Shrub sp. (≤0.5m)						
Shrub/tree(>0.5 to 3m)						
Tree (>3 m)						

UTM, NAD83

mE	1	
mN		
mE	2	
mN		
mE	3	
mN		
mE	4	
mN		
mE	5	
mN		
mE	6	
mN		

WITHIN ENTIRE PLOT:
Place an X to indicate presence:

Vertical cliff >100' high	
Tank w/ standing water	
Burned habitat (any evidence)	
OHV use evidence ≤ 1 year	
Livestock evidence ≤ 1 year	
Other (describe)	
Invasive Plants	
Sahara mustard	
Red brome	
Buffelgrass	
Arabian Mediterranean grass	
Bermuda grass	
Fountain grass	
Russian thistle	

Mistletoe (estimate # of mistletoe clumps within **100 m of point, 360°**)
Category (Low, Medium, or High): Use **0 (none), L (<10), M (10-50), H (>50)**

Mistletoe clumps:						

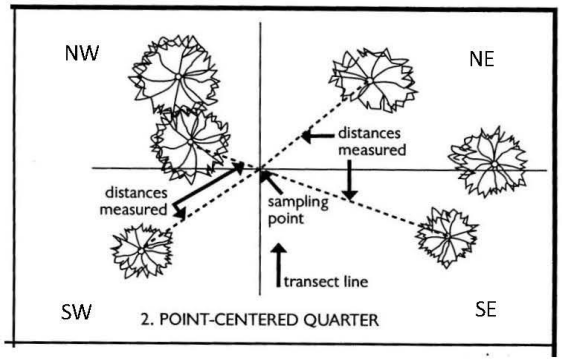
Saguaro Count (while standing at veg. pt., count all saguaros within a **100 m** radius; 360°)

Armed						
Unarmed						

Grass/forb ground cover (live/dead) (at veg. pt. along **50 m** line in North direction)

# of meters "native"						
# of meters invasive						

NOTES:



2. POINT-CENTERED QUARTER

Lower Sonoran Desert Bird Monitoring - Le Conte's Thrasher Survey

Date *(eg 3-Dec-12)* **:** **Observer(s)** *(list all)**:

Plot Number:

In the "Pass" columns, put an "S" in the appropriate column if the bird was seen, a "1" if the bird was heard, and "1S" if both heard and seen

Station#	NAD83 Easting	NAD83 Northing	Temp C or F	Sky	Wind	Noise	Start Time (military)	Species	Responded During							LCTH Vocal Type(s)	Detected at a Previous Point	Was LCTH in plot before responding? Other comments?
									Pass 1 (0-1)	Pass 2 (1-2)	Pass 3 (2-3)	Pass 4 (3-4)	Pass 5 (4-5)	Pass 6 (5-6)	Outside survey period			

Sky: 0 *clear or a few clouds* 1 *partly cloud or variable sky* 2 *cloudy or overcast* 4 *fog or smoke* 5 *drizzle* 6 *snow* 8 *showers*

Wind (Beaufort) scale: 0 *smoke rises vertically* 1 *wind direction shown by smoke drift* 2 *wind felt on face; leaves rustle* 3 *leaves , small twigs in constant motion; light flag extended* 4 *raises dust and loose paper; small branches are moved* 5 *small trees with leaves sway; crested wavelets on inland waters*

Noise: 0 *no noise* 1 *faint noise* 2 *moderate noise (probably can't hear some birds beyond 100m)* 3 *loud noise (probably can't hear some birds beyond 50m)* 4 *intense noise (probably can't hear some birds beyond 25m)*

LCTH Vocal Types: 1 typical male song 2 "drip" call 3 Other (please describe)

APPENDIX B: SUMMARY OF BREEDING BIRDS RECORDED 2012-2014

Species	Scientific Name	N Birds	N Plots	Density (birds/km^2)	Population Size	CV
Abert's Towhee	*Melozone aberti*	19	9	0.8	55,012	0.49
American Kestrel	*Falco sparverius*	85	39	2.1	143,929	0.26
Anna's Hummingbird[2]	*Calypte anna*	5	2			
Ash-throated Flycatcher	*Myiarchus cinerascens*	1210	246	30.4	2,102,037	0.20
Bell's Vireo	*Vireo bellii*	33	8	1.4	98,715	0.53
Bendire's Thrasher	*Toxostoma bendirei*	34	13	1	67,900	0.36
Bewick's Wren	*Thryomanes bewickii*	22	8	0.9	63,633	0.45
Black-chinned Hummingbird[2,3]	*Archilochus alexandri*	2	1			
Black-chinned Sparrow[2,3]	*Spizella atrogularis*	1	1			
Black-tailed Gnatcatcher	*Polioptila melanura*	1454	236	36	2,488,940	0.19
Black-throated Sparrow	*Amphispiza bilineata*	1982	252	48.9	3,382,580	0.20
Blue Grosbeak[2]	*Passerina caerulea*	1	1			
Blue-gray Gnatcatcher[3]	*Polioptila caerulea*	4	1	0.1	7280	1.02
Bronzed Cowbird[2]	*Molothrus aeneus*	2	1			
Brown-crested Flycatcher	*Myiarchus tyrannulus*	169	36	6.2	432,362	0.27
Brown-headed Cowbird[2]	*Molothrus ater*	150	41			
Burrowing Owl	*Athene cunicularia*	2	1	0	2440	1.02
Cactus Wren	*C. brunneicapillus*	1108	178	32.8	2,269,339	0.21
Canyon Towhee	*Melozone fusca*	222	58	7.1	491,460	0.24
Canyon Wren	*Catherpes mexicanus*	45	14	1.2	85,169	0.36
Chihuahuan Raven	*Corvus cryptoleucus*	16	1	1.3	90,098	1.02
Common Ground Dove	*Columbina passerina*	5	2	0.4	28,156	0.83
Common Poorwill	*Phalaenoptilus nuttallii*	23	11	0.6	42,364	0.36
Common Raven	*Corvus corax*	35	15	1.1	77,878	0.46
Costa's Hummingbird[2]	*Calypte costae*	354	132			
Crested Caracara	*Caracara cheriway*	2	2	0.2	11,262	0.71
Crissal Thrasher	*Toxostoma crissale*	42	18	1	71,532	0.33
Curve-billed Thrasher	*Toxostoma curvirostre*	622	96	18	1,242,181	0.22
Elf Owl	*Micrathene whitneyi*	9	4	0.3	17,832	0.58
Eurasian Collared-Dove	*Streptopelia decaocto*	3	2	0.1	3933	0.73
European Starling	*Sturnus vulgaris*	2	1	0.1	3640	1.02
Gambel's Quail	*Callipepla gambelii*	1083	145	27.2	1,885,159	0.23
Gila Woodpecker	*Melanerpes uropygialis*	498	112	13.9	958,884	0.22
Gilded Flicker	*Colaptes chrysoides*	277	93	7.5	518,947	0.23
Great Horned Owl	*Bubo virginianus*	15	7	0.3	19,528	0.49
Greater Roadrunner	*G. californianus*	51	24	1.2	80,364	0.31
Harris's Hawk	*Parabuteo unicinctus*	3	2	0.1	5,682	1.01
Hooded Oriole	*Icterus cucullatus*	20	8	0.8	55,722	0.46
Horned Lark	*Eremophila alpestris*	124	28	1.5	102,898	0.29
House Finch	*Haemorhous mexicanus*	879	146	20.5	1,418,759	0.23
House Sparrow	*Passer domesticus*	4	1	0.1	7,280	1.02
Juniper Titmouse[3]	*Baeolophus ridgwayi*	6	1	0.2	10,920	1.02
Killdeer[2]	*Charadrius vociferus*	1	1			

[1] N birds is the number of birds (excluding incidentals) recorded on rapid surveys using the method described in the text to estimate how many birds were present on the plots. N plots is the number of plots on which the species was detected during rapid surveys. Density (birds/km^2), Population size, and CV are the estimated density and total number of birds within the study area and the CV for these estimates (the CV is the same for density and population size).

[2] Estimates not reported because species is non-monogamous or only 1 individual was recorded.

[3] Non-traditional Sonoran Desert breeding species detected on a few plots which included some riparian-edge (Black-chinned Hummingbird and Lesser Goldfinch) or chaparral/juniper-edge (Blue-gray Gnatcatcher, Juniper Titmouse, and Black-chinned Sparrow) habitat.

Species	Scientific Name	N Birds	N Plots	Density (birds/km^2)	Population Size	CV
Ladder-backed Woodpecker	*Picoides scalaris*	239	93	6.6	455,207	0.22
Lark Sparrow[2]	*Chondestes grammacus*	1	1			
Le Conte's Thrasher	*Toxostoma lecontei*	51	20	0.7	48,402	0.33
Lesser Goldfinch[3]	*Spinus psaltria*	7	3	0.5	31,796	0.75
Lesser Nighthawk	*Chordeiles acutipennis*	132	47	10.6	732,879	0.42
Loggerhead Shrike	*Lanius ludovicianus*	263	108	5	348,331	0.21
Long-eared Owl	*Asio otus*	2	1	0	1,249	1.02
Lucy's Warbler	*Oreothlypis luciae*	327	56	28.7	1,983,448	0.28
Mourning Dove	*Zenaida macroura*	943	177	21.4	1,479,862	0.20
Northern Cardinal	*Cardinalis cardinalis*	66	21	2.3	157,684	0.31
Northern Mockingbird	*Mimus polyglottos*	267	86	5.7	397,711	0.22
Phainopepla	*Phainopepla nitens*	588	117	12.6	871,309	0.22
Purple Martin	*Progne subis*	13	6	0.8	57,960	0.45
Pyrrhuloxia	*Cardinalis sinuatus*	81	23	3.2	223,866	0.46
Red-tailed Hawk	*Buteo jamaicensis*	25	12	0.6	42,458	0.47
Rock Wren	*Salpinctes obsoletus*	195	54	4.5	311,007	0.25
Rufous-crowned Sparrow	*Aimophila ruficeps*	6	2	0.2	12,371	0.74
Rufous-winged Sparrow	*Peucaea carpalis*	53	11	2.7	184,874	0.49
Say's Phoebe	*Sayornis saya*	51	24	0.9	61,758	0.29
Scott's Oriole	*Icterus parisorum*	108	36	3.3	225,290	0.27
Turkey Vulture	*Cathartes aura*	4	2	0.1	7,280	0.73
Varied Bunting	*Passerina versicolor*	2	2	0.2	11,262	0.71
Verdin	*Auriparus flaviceps*	1,445	215	36.4	2,518,847	0.20
Vermilion Flycatcher	*Pyrocephalus rubinus*	5	2	0.1	9,100	0.84
Western Kingbird	*Tyrannus verticalis*	33	12	0.8	56,570	0.39
Western Meadowlark	*Sturnella neglecta*	16	1	0.1	9,995	1.02
Western Screech-Owl	*Megascops kennicottii*	28	12	0.7	50,054	0.35
White-throated Swift	*Aeronautes saxatalis*	16	2	0.3	21,923	0.77
White-winged Dove	*Zenaida asiatica*	317	91	25.7	1,780,909	0.24

[1] N birds is the number of birds (excluding incidentals) recorded on rapid surveys using the method described in the text to estimate how many birds were present on the plots. N plots is the number of plots on which the species was detected during rapid surveys. Density (birds/km^2), Population size, and CV are the estimated density and total number of birds within the study area and the CV for these estimates (the CV is the same for density and population size).

[2] Estimates not reported because species is non-monogamous or only 1 individual was recorded.

[3] Non-traditional Sonoran Desert breeding species detected on a few plots which included some riparian-edge (Black-chinned Hummingbird and Lesser Goldfinch) or chaparral/juniper-edge (Blue-gray Gnatcatcher, Juniper Titmouse, and Black-chinned Sparrow) habitat.

APPENDIX C: SPECIES ACCOUNTS

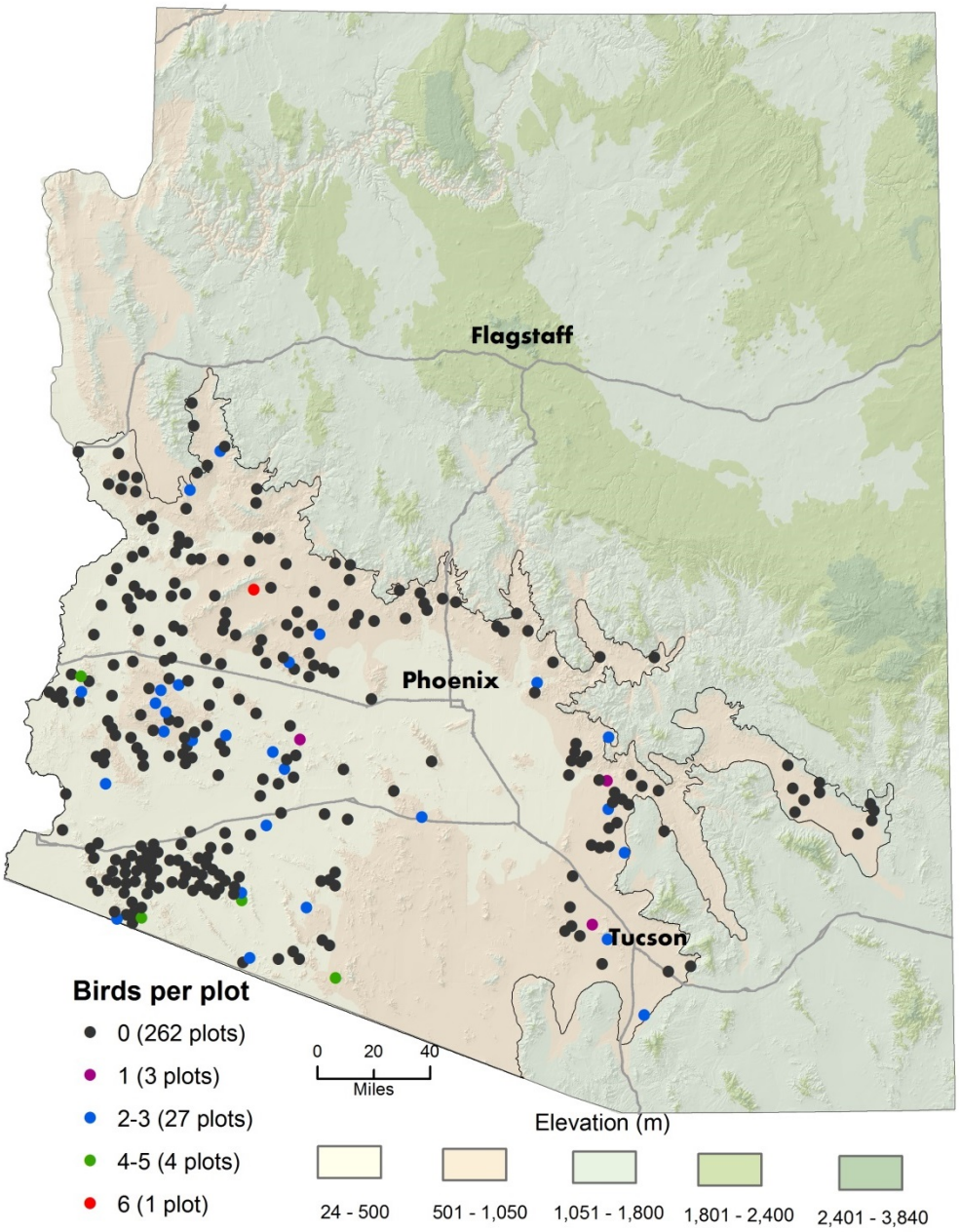
This appendix presents distribution maps and tables for 40 of the species most commonly recorded. Maps show the numbers of birds recorded per plot throughout the study area. Background features include elevation, major roads, and cities.

The tables show the following data by region and for the entire study area: number of birds recorded, number of plots with at least 1 record of the species, estimated density (birds/km^2), estimated population size throughout the study area, and the CV which applies to both of the estimates. SEs may be calculated as follows:

SE(density) = CV * estimated density
SE(population size) = CV * estimated population size

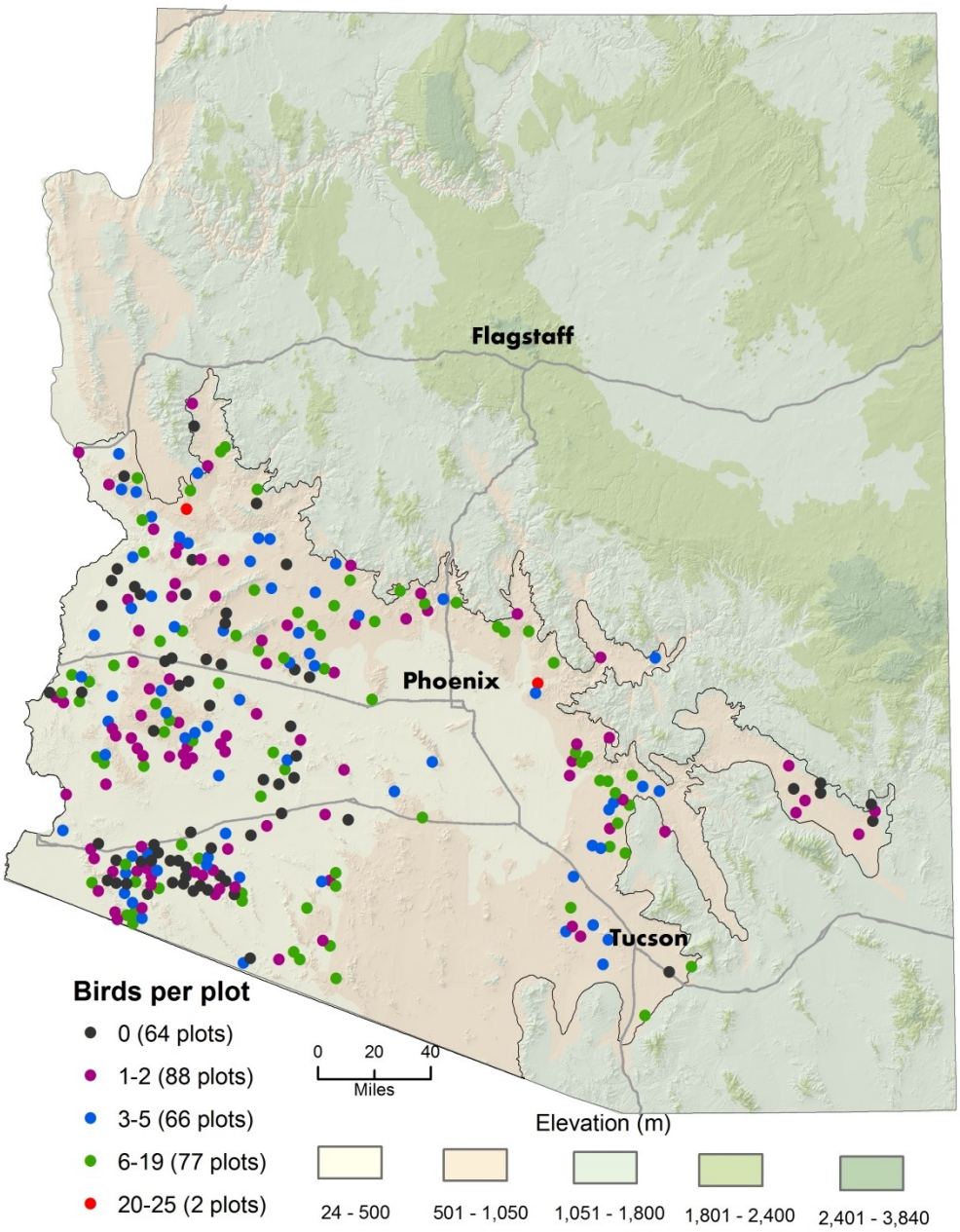
No.	Species	No.	Species
1	American Kestrel	21	House Finch
2	Ash-throated Flycatcher	22	Ladder-backed Woodpecker
3	Bell's Vireo	23	Le Conte's Thrasher
4	Bendire's Thrasher	24	Lesser Nighthawk
5	Black-tailed Gnatcatcher	25	Loggerhead Shrike
6	Black-throated Sparrow	26	Lucy's Warbler
7	Brown-crested Flycatcher	27	Mourning Dove
8	Brown-headed Cowbird	28	Northern Cardinal
9	Cactus Wren	29	Northern Mockingbird
10	Canyon Towhee	30	Phainopepla
11	Canyon Wren	31	Pyrrhuloxia
12	Common Raven	32	Red-tailed Hawk
13	Costa's Hummingbird	33	Rock Wren
14	Crissal Thrasher	34	Rufous-winged Sparrow
15	Curve-billed Thrasher	35	Say's Phoebe
16	Gambel's Quail	36	Scott's Oriole
17	Gila Woodpecker	37	Verdin
18	Gilded Flicker	38	Western Kingbird
19	Greater Roadrunner	39	Western Screech-Owl
20	Horned Lark	40	White-winged Dove

American Kestrel



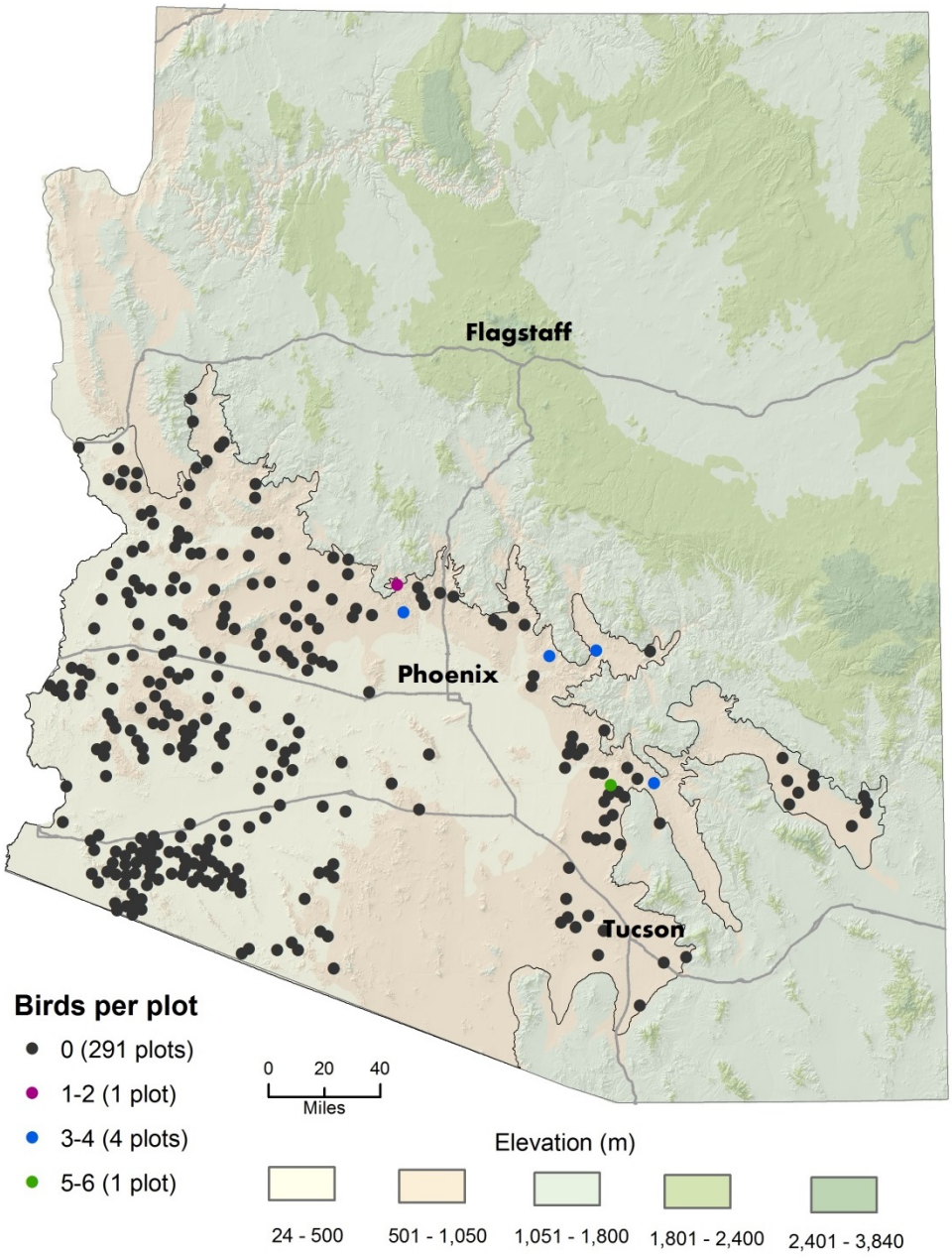
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	36	15	1.3	30,533	0.33
Upper	49	24	2.3	113,837	0.29
Both	85	39	2.1	143,929	0.26

Ash-throated Flycatcher



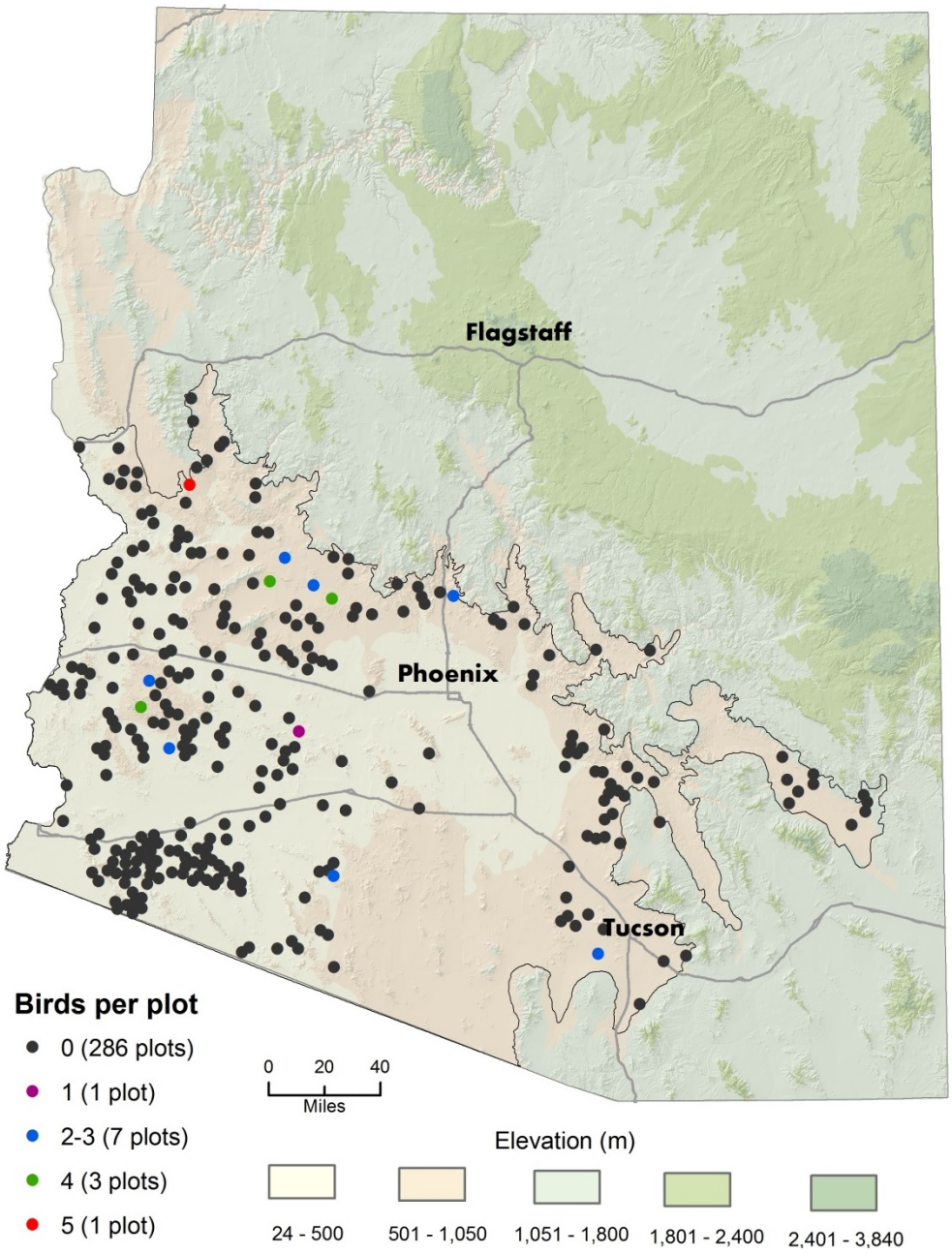
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	443	97	17.3	392,044	0.20
Upper	767	149	36.5	1,718,778	0.19
Both	1,210	246	30.4	2,102,037	0.20

Bell's Vireo



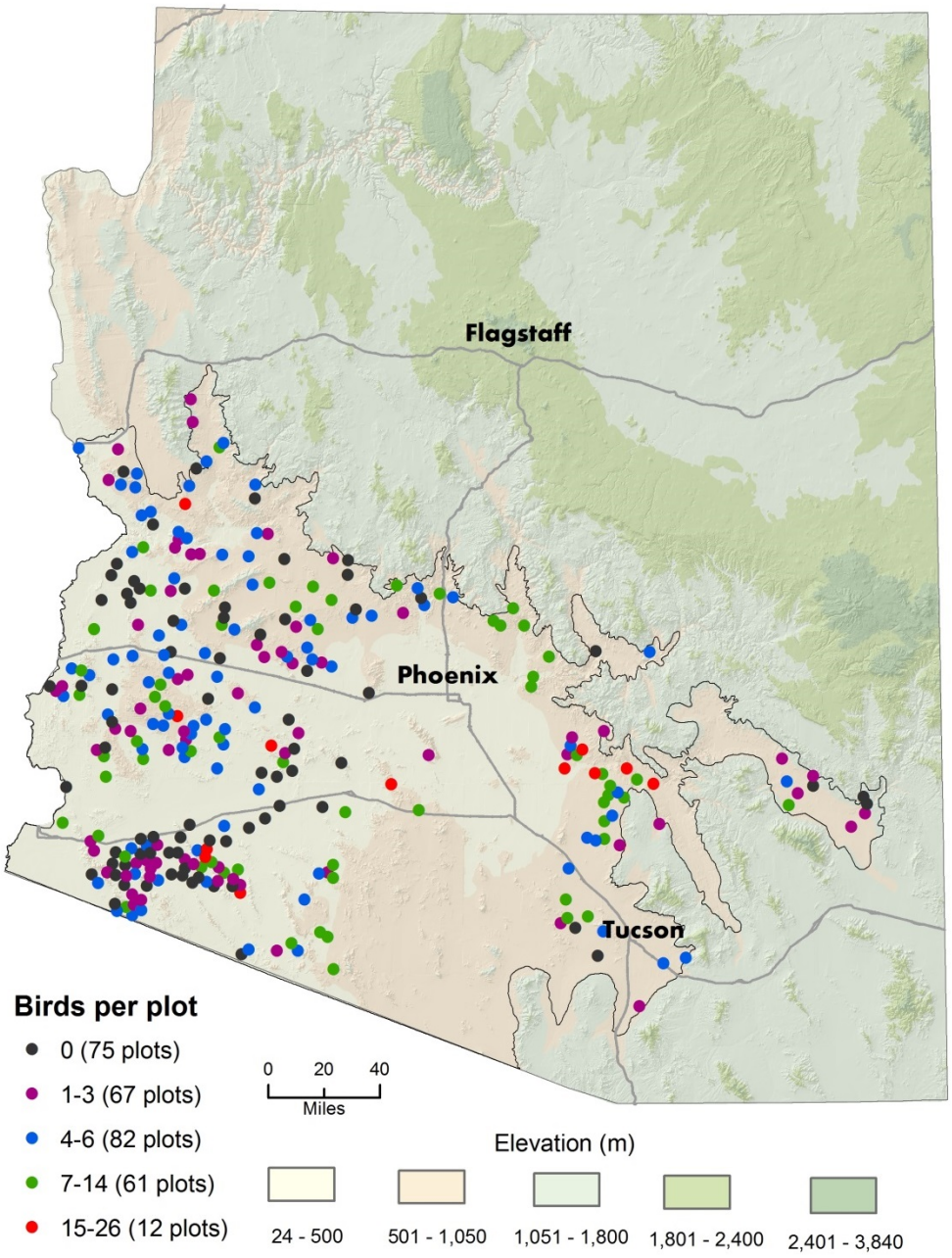
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	0	0	0.0	0	-
Upper	33	8	1.8	98,715	0.44
Both	33	8	1.4	98,715	0.53

Bendire's Thrasher



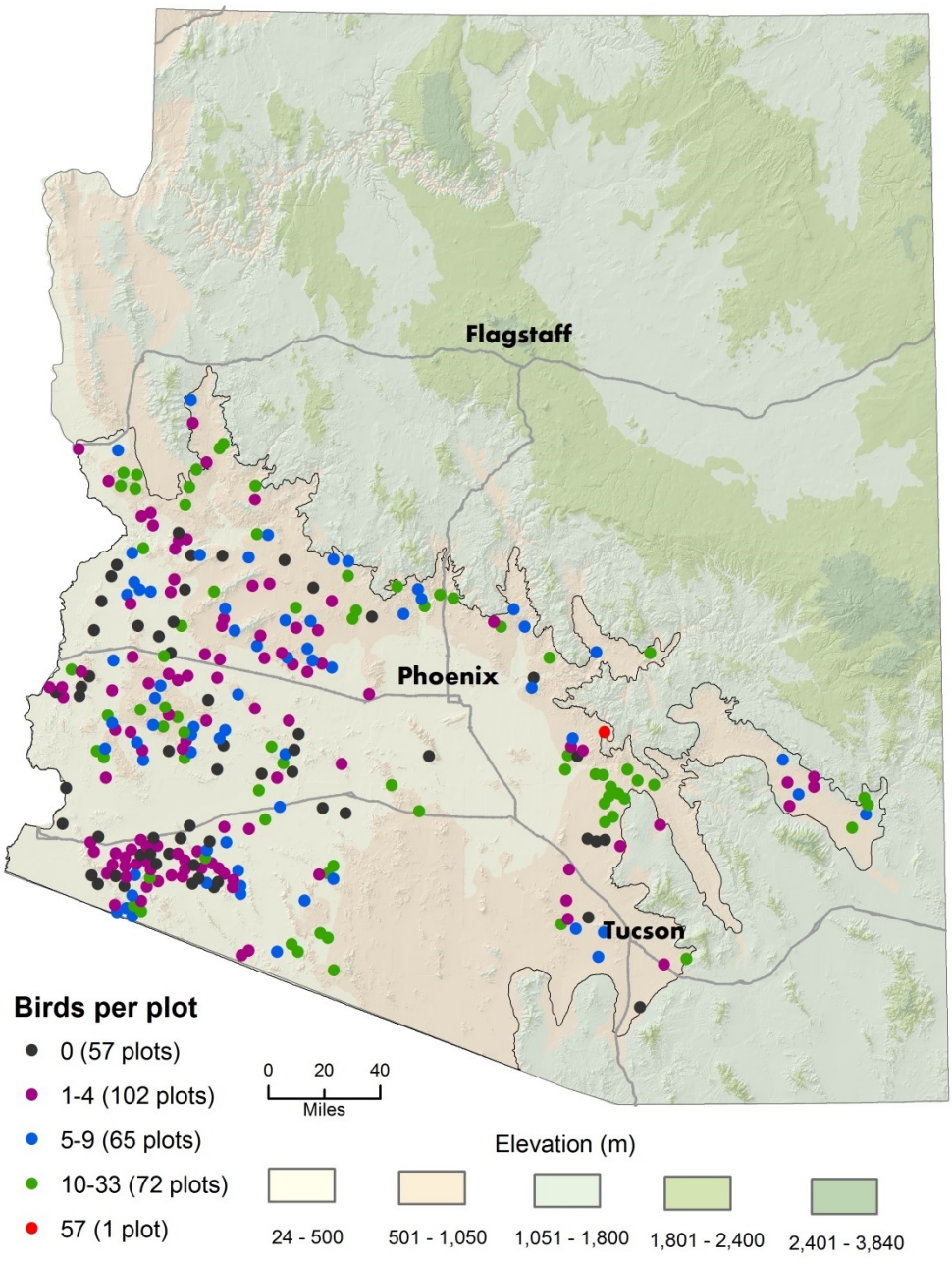
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	4	2	0.2	4,146	0.73
Upper	30	11	1.5	64,248	0.41
Both	34	13	1.0	67,900	0.36

Black-tailed Gnatcatcher



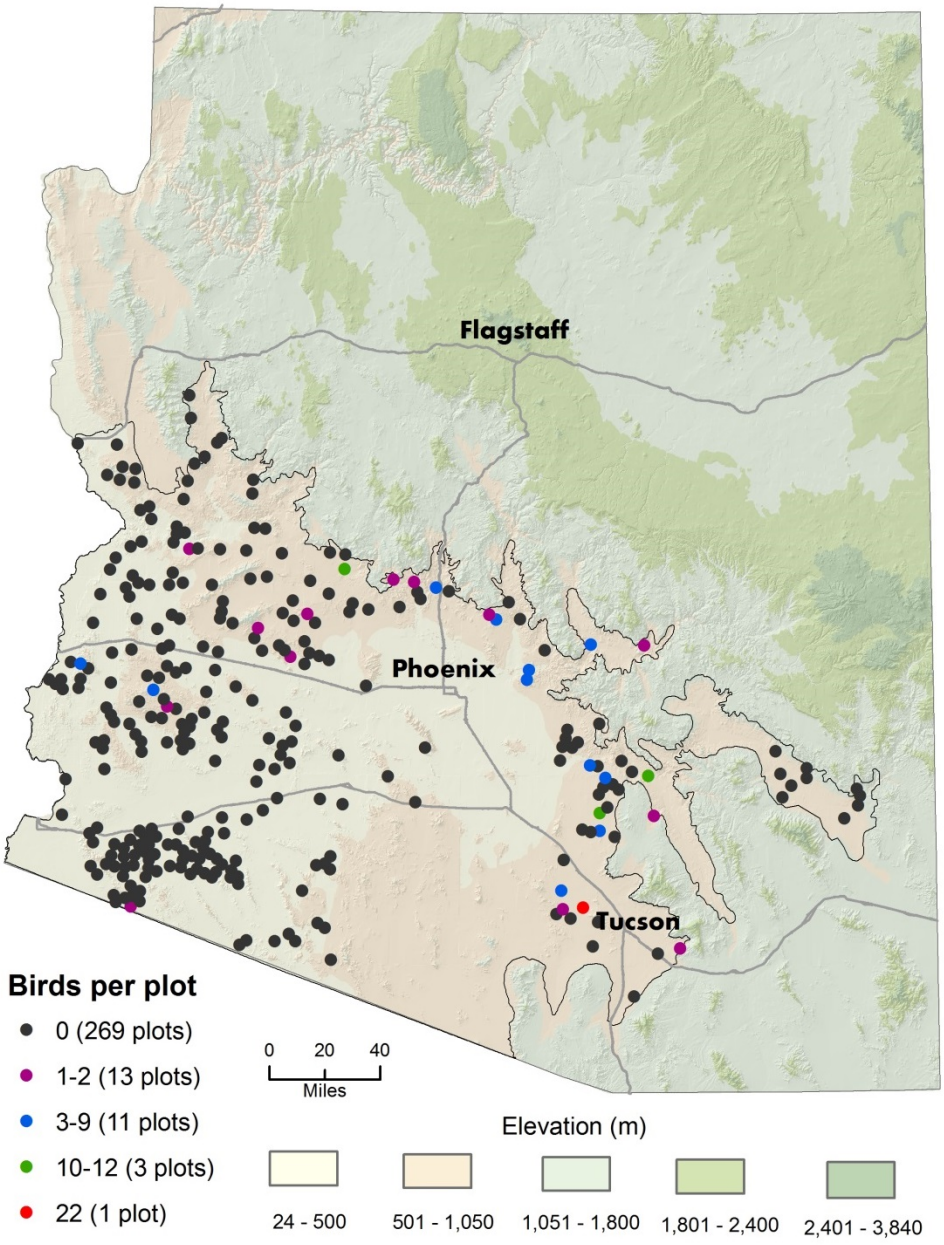
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	554	96	21.5	480,455	0.20
Upper	900	140	42.7	2,018,007	0.19
Both	1,454	236	36.0	2,488,940	0.19

Black-throated Sparrow



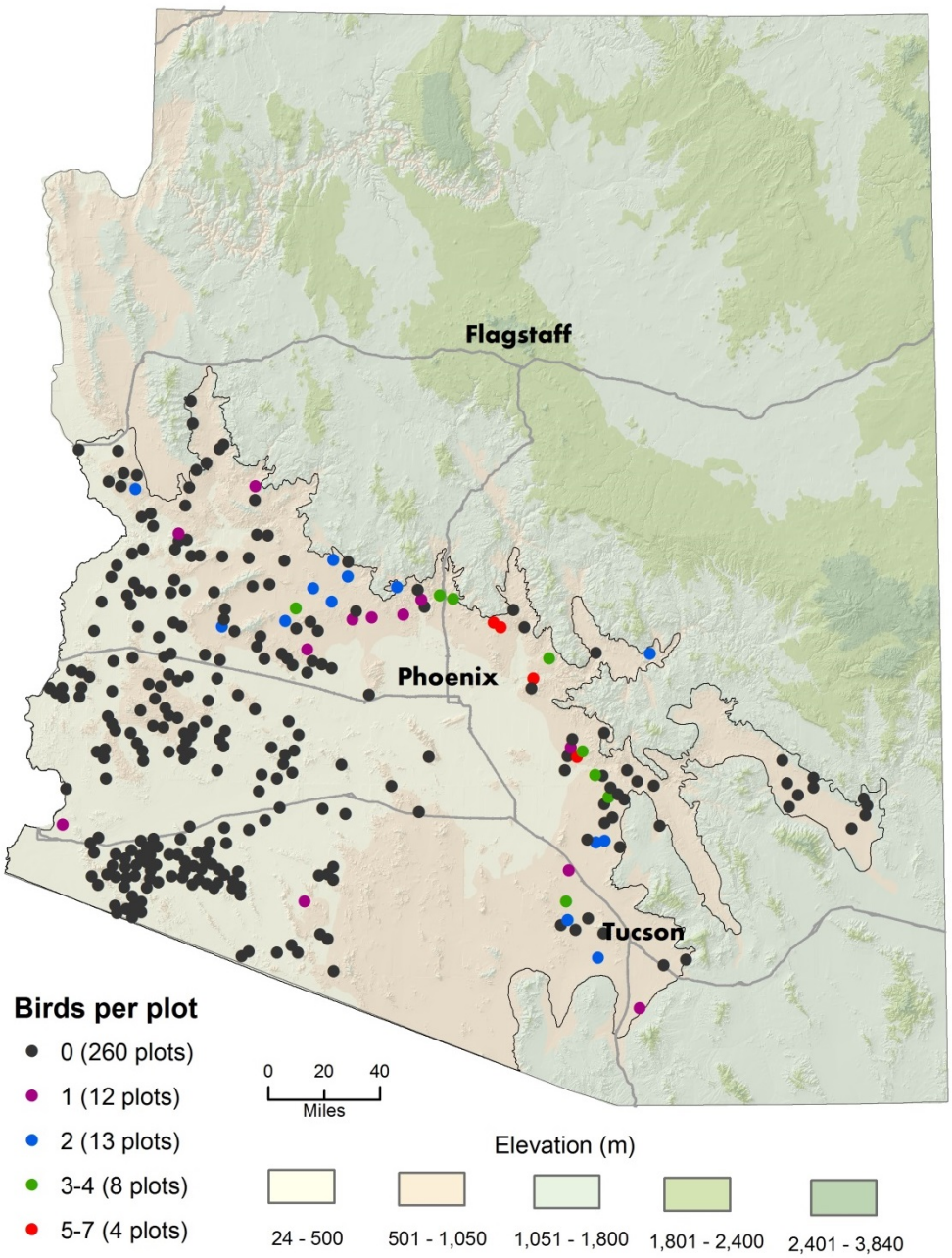
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	719	107	26.9	605,305	0.19
Upper	1,263	145	64.3	2,792,289	0.18
Both	1,982	252	48.9	3,382,580	0.20

Brown-crested Flycatcher



Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	4	2	0.2	3,742	0.76
Upper	165	34	8.3	432,417	0.30
Both	169	36	6.2	432,362	0.27

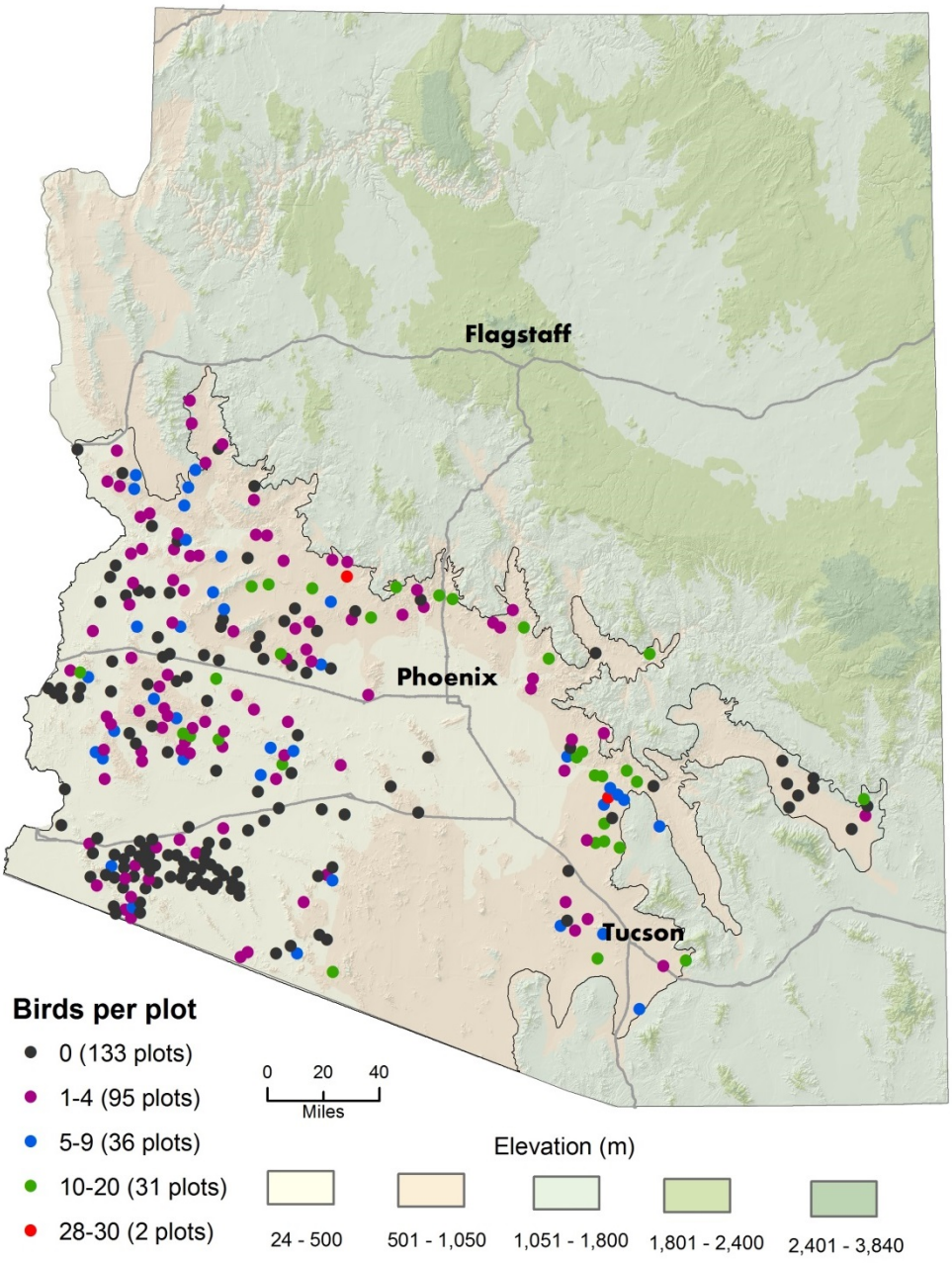
Brown-headed Cowbird



Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	8	4	-	-	-
Upper	142	37	-	-	-
Both	150	41	-	-	-

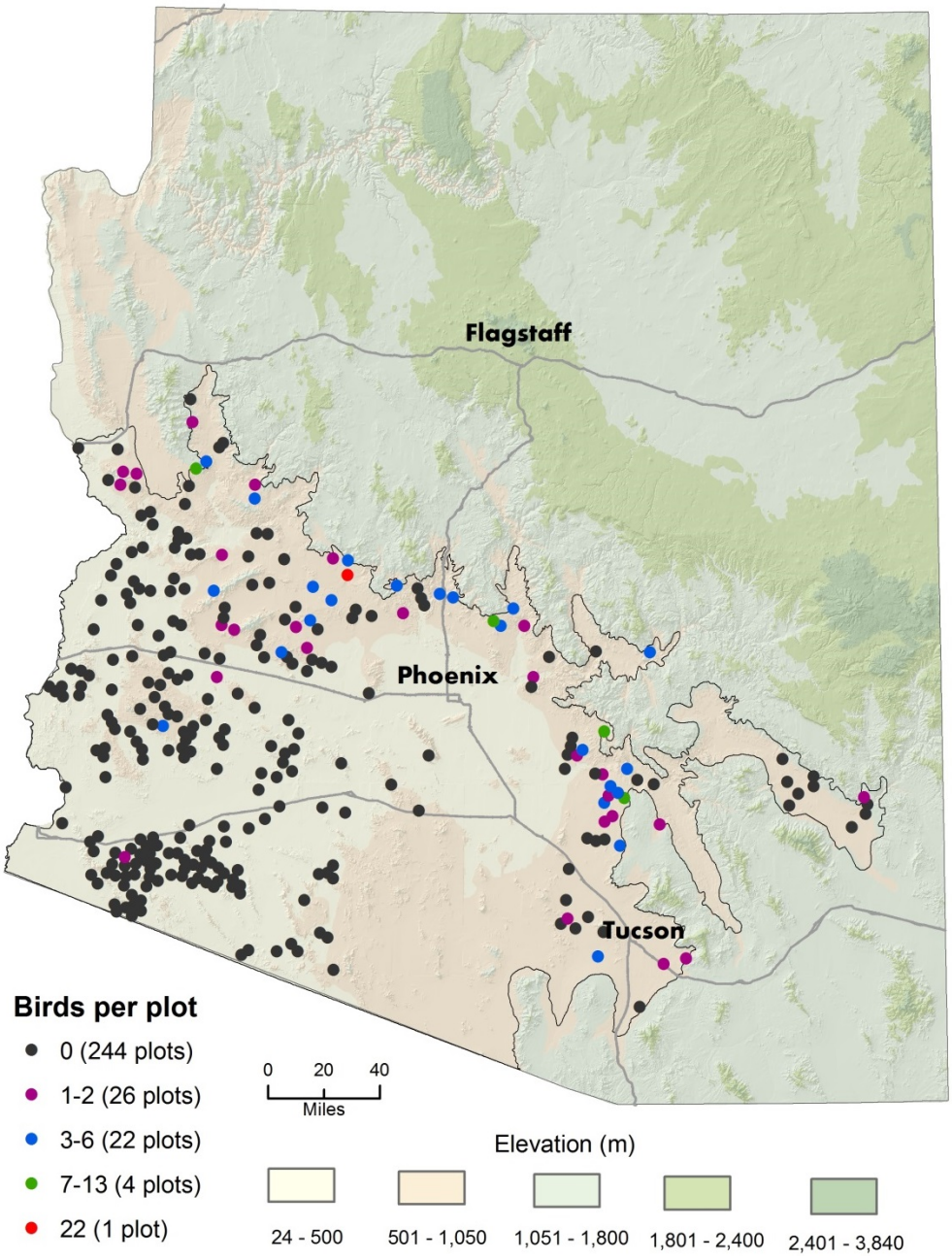
Density and population size not estimated because the species is not monogamous.

Cactus Wren



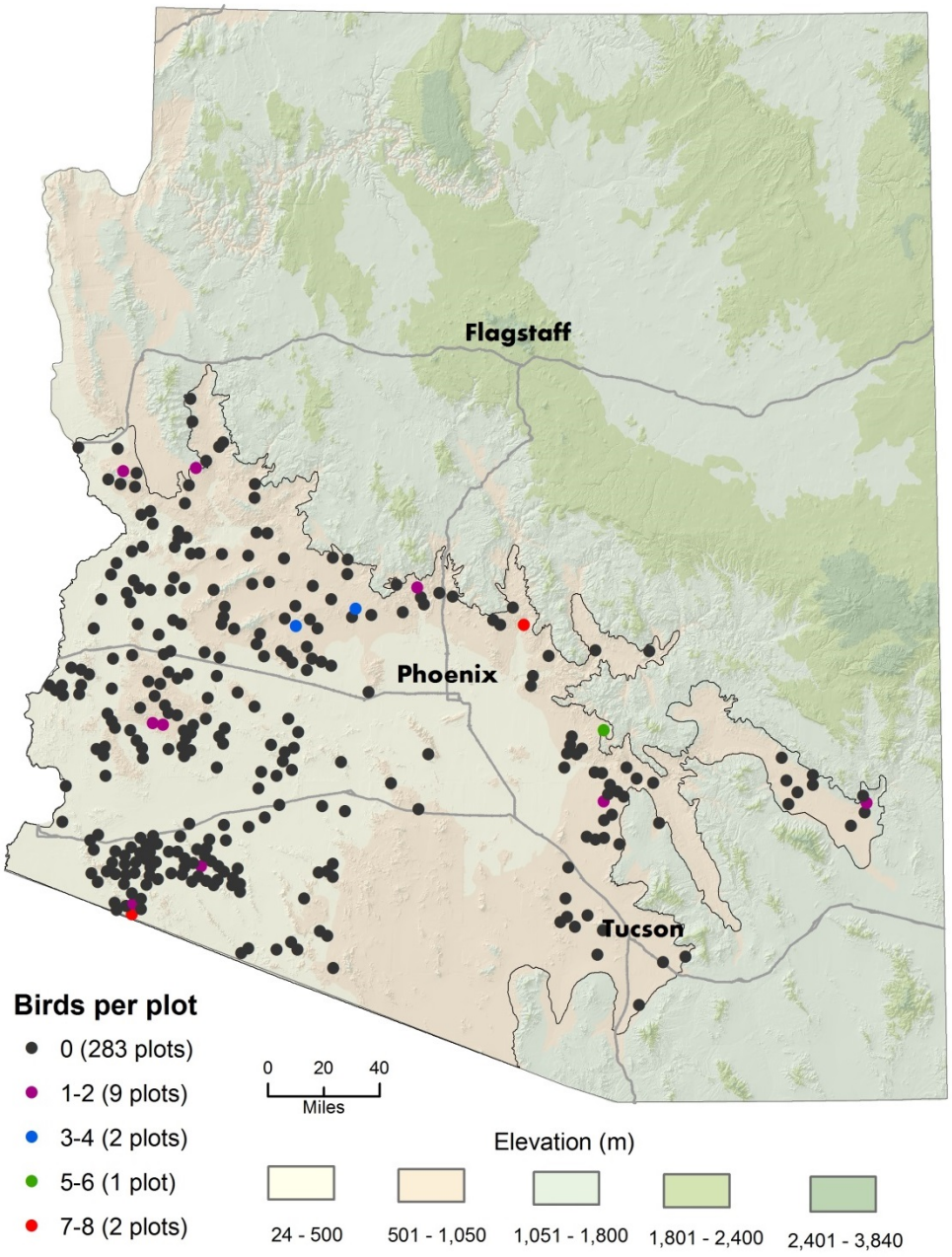
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	248	51	10.9	234,721	0.22
Upper	860	126	41.9	2,049,153	0.20
Both	1,108	177	32.8	2,269,339	0.21

Canyon Towhee



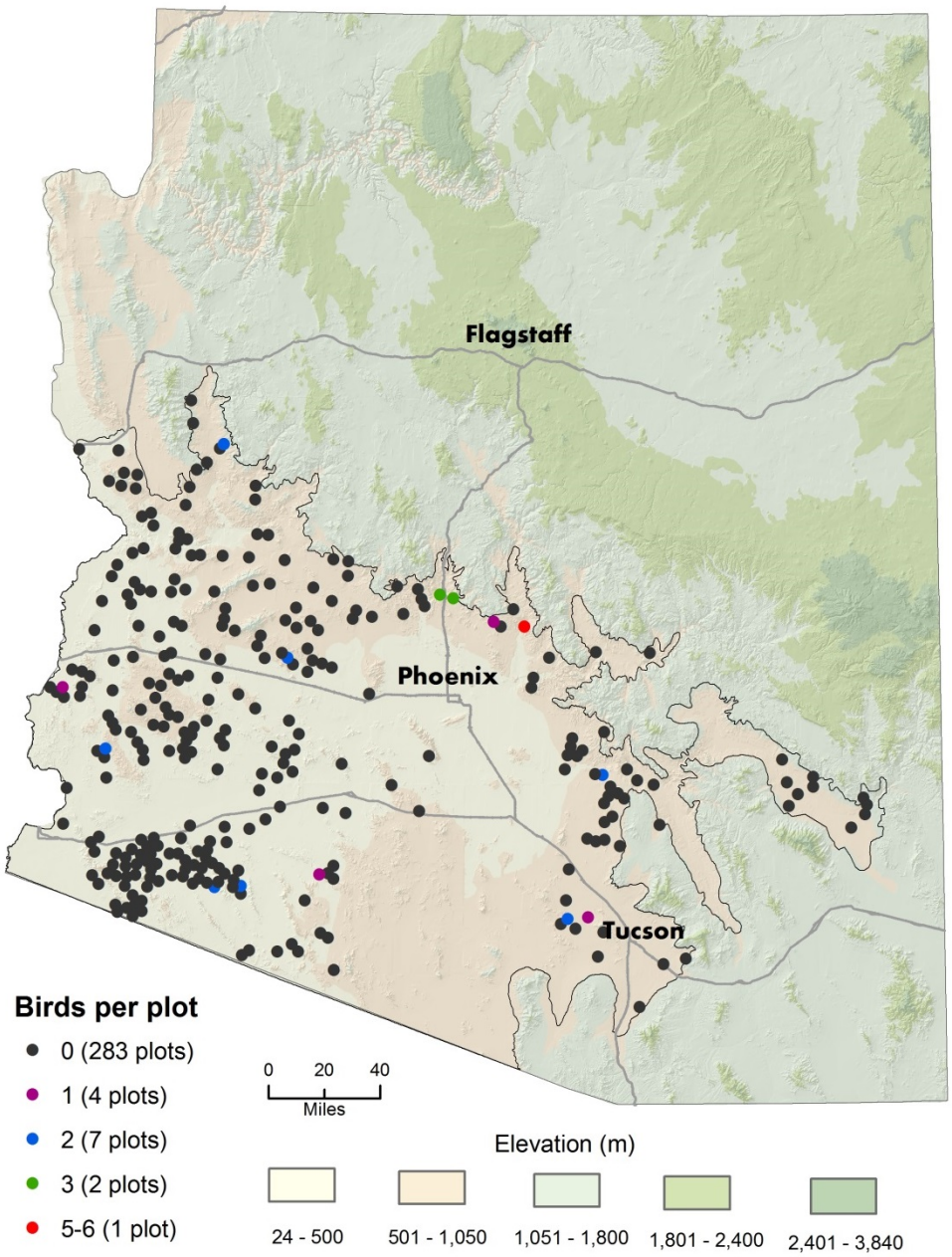
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	9	3	0.7	14,278	0.62
Upper	213	55	11.2	481,642	0.22
Both	222	58	7.1	491,460	0.24

Canyon Wren



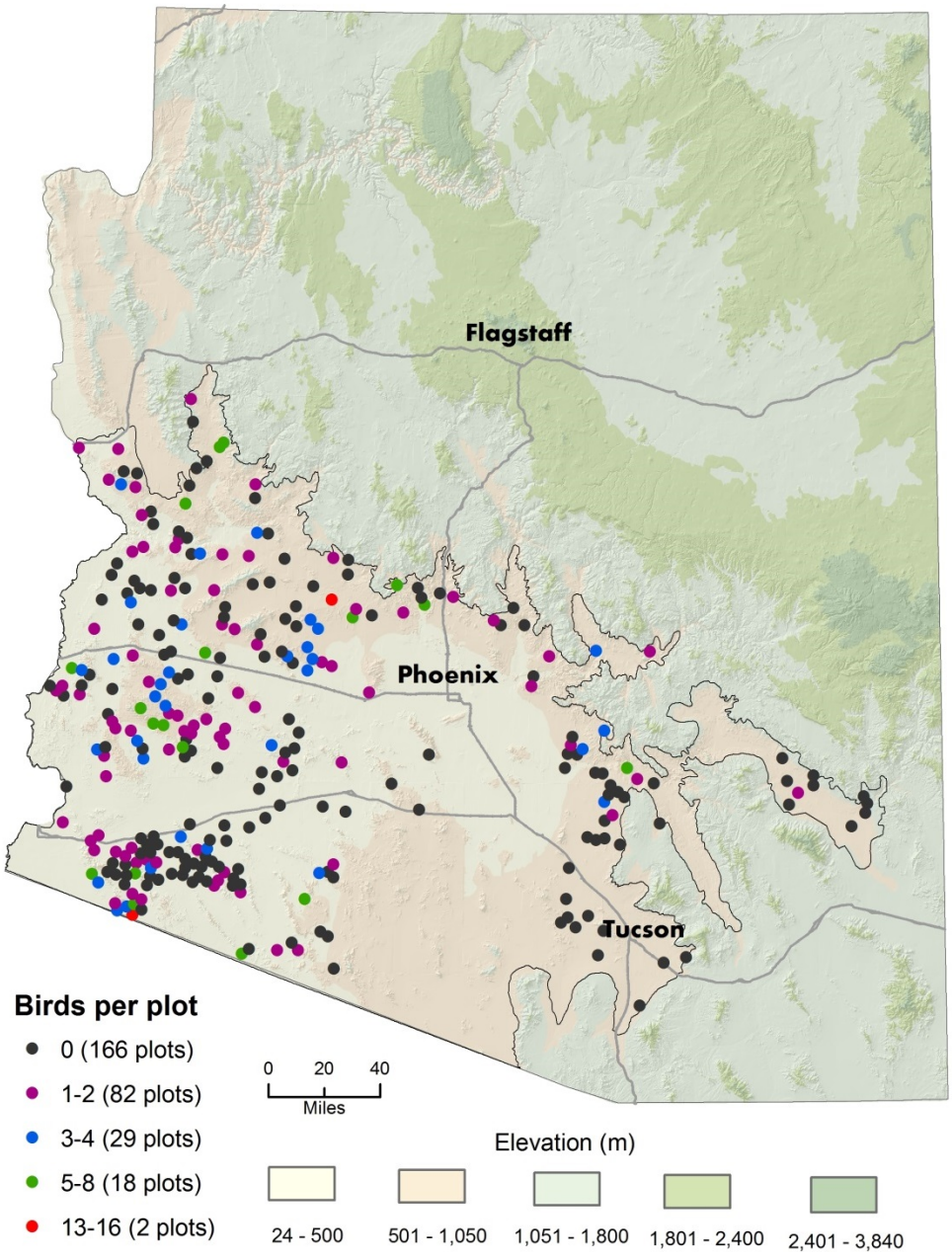
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	10	3	0.3	8,345	0.72
Upper	35	11	2.0	77,567	0.28
Both	45	14	1.2	85,169	0.36

Common Raven



Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	8	5	0.3	7,406	0.66
Upper	27	10	1.4	71,013	0.43
Both	35	15	1.1	77,878	0.46

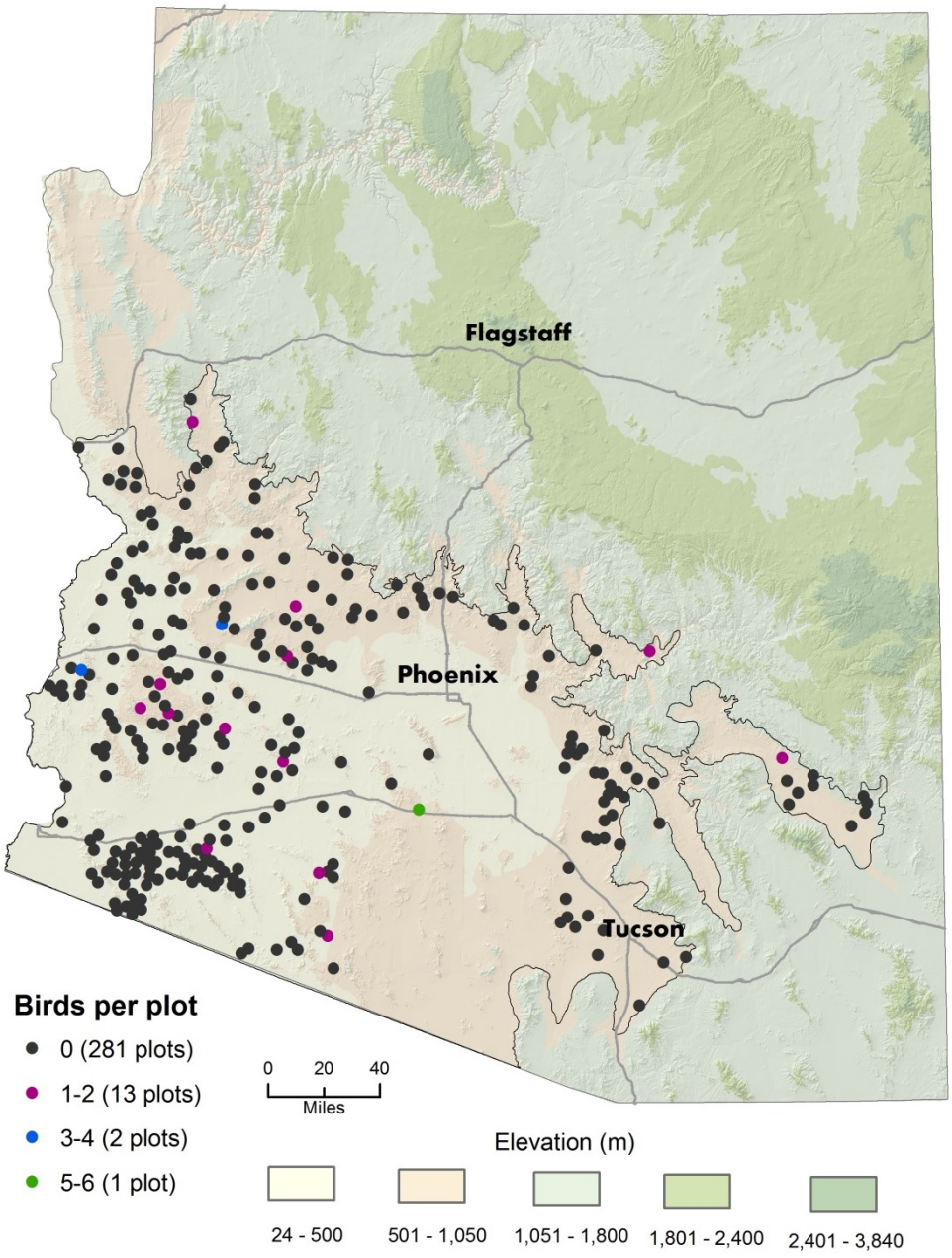
Costa's Hummingbird



Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	137	55	-	-	-
Upper	217	77	-	-	-
Both	354	132	-	-	-

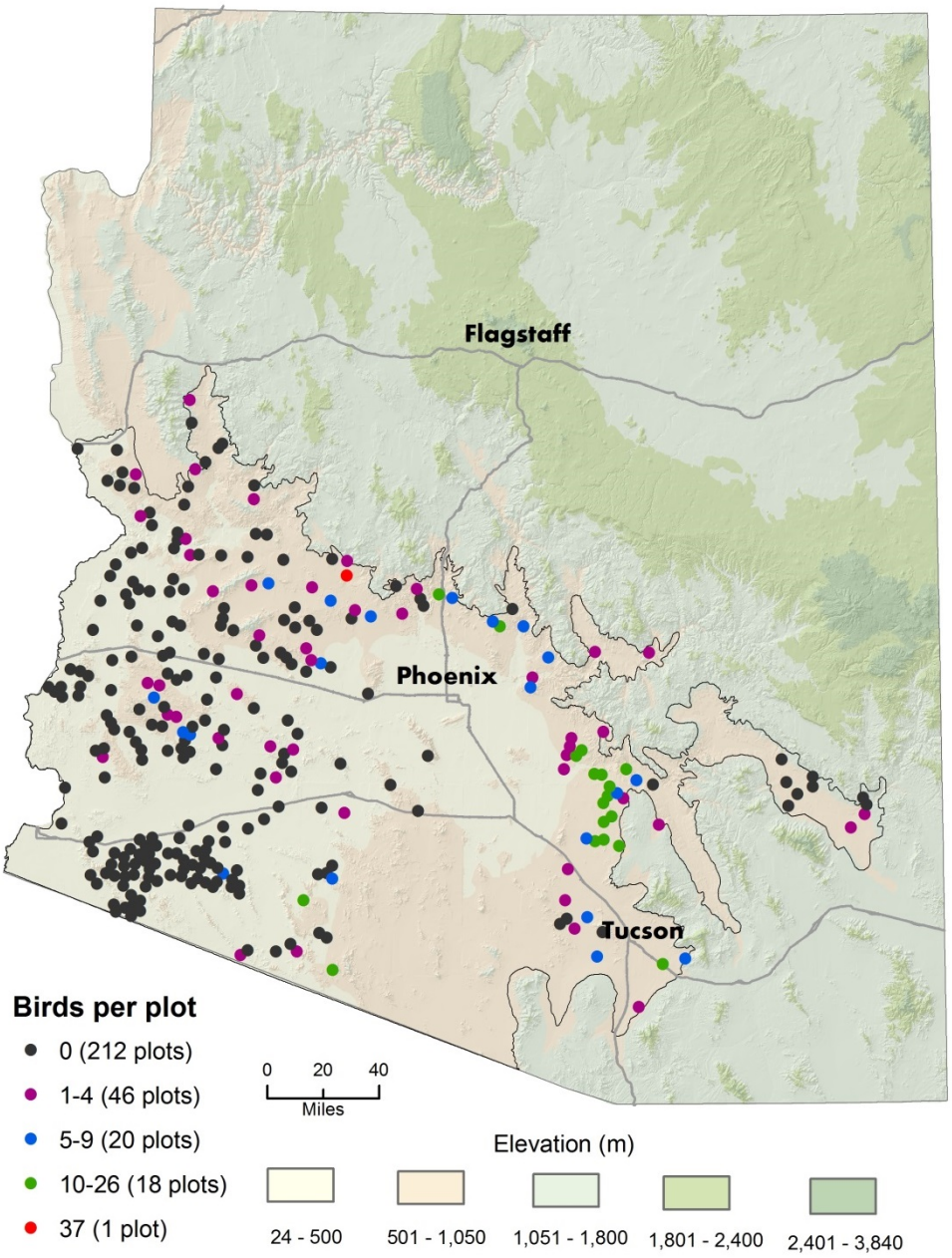
Density and population size not estimated because the species is not monogamous.

Crissal Thrasher



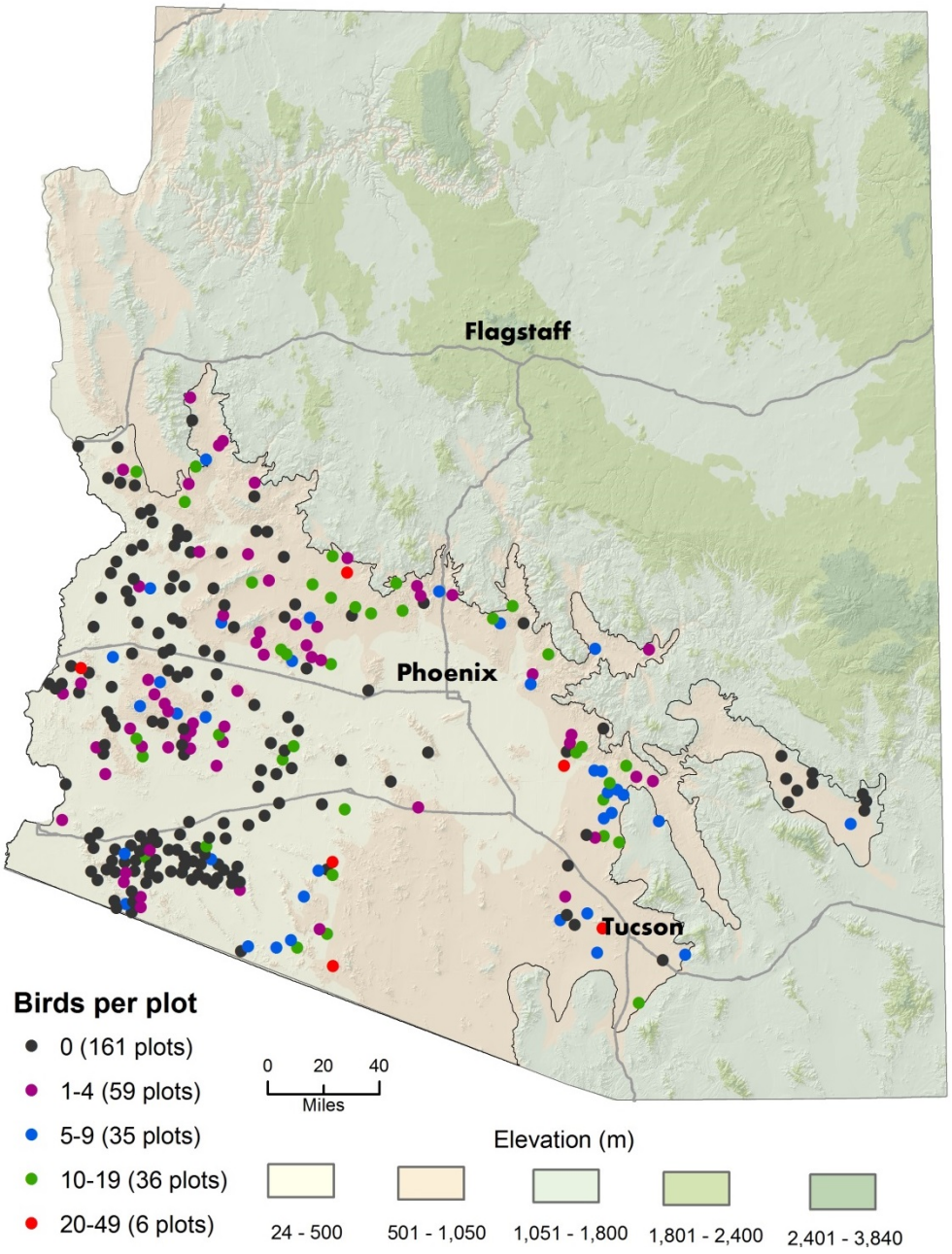
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	16	6	0.7	14,888	0.54
Upper	26	12	1.1	56,849	0.41
Both	42	18	1.0	71,532	0.33

Curve-billed Thrasher



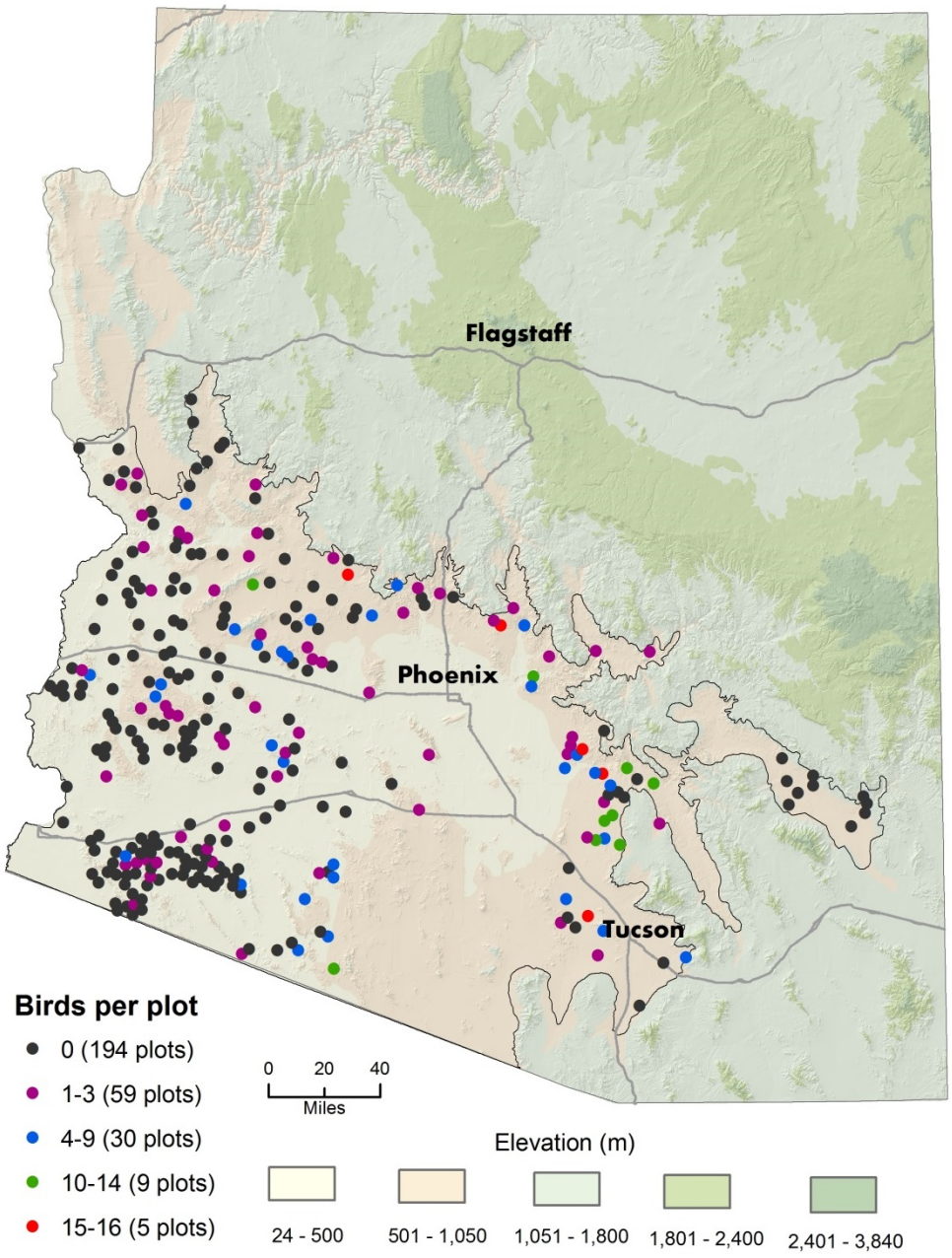
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	90	20	3.8	81,621	0.34
Upper	532	76	26.1	1,169,714	0.23
Both	622	96	18.0	1,242,181	0.22

Gambel's Quail



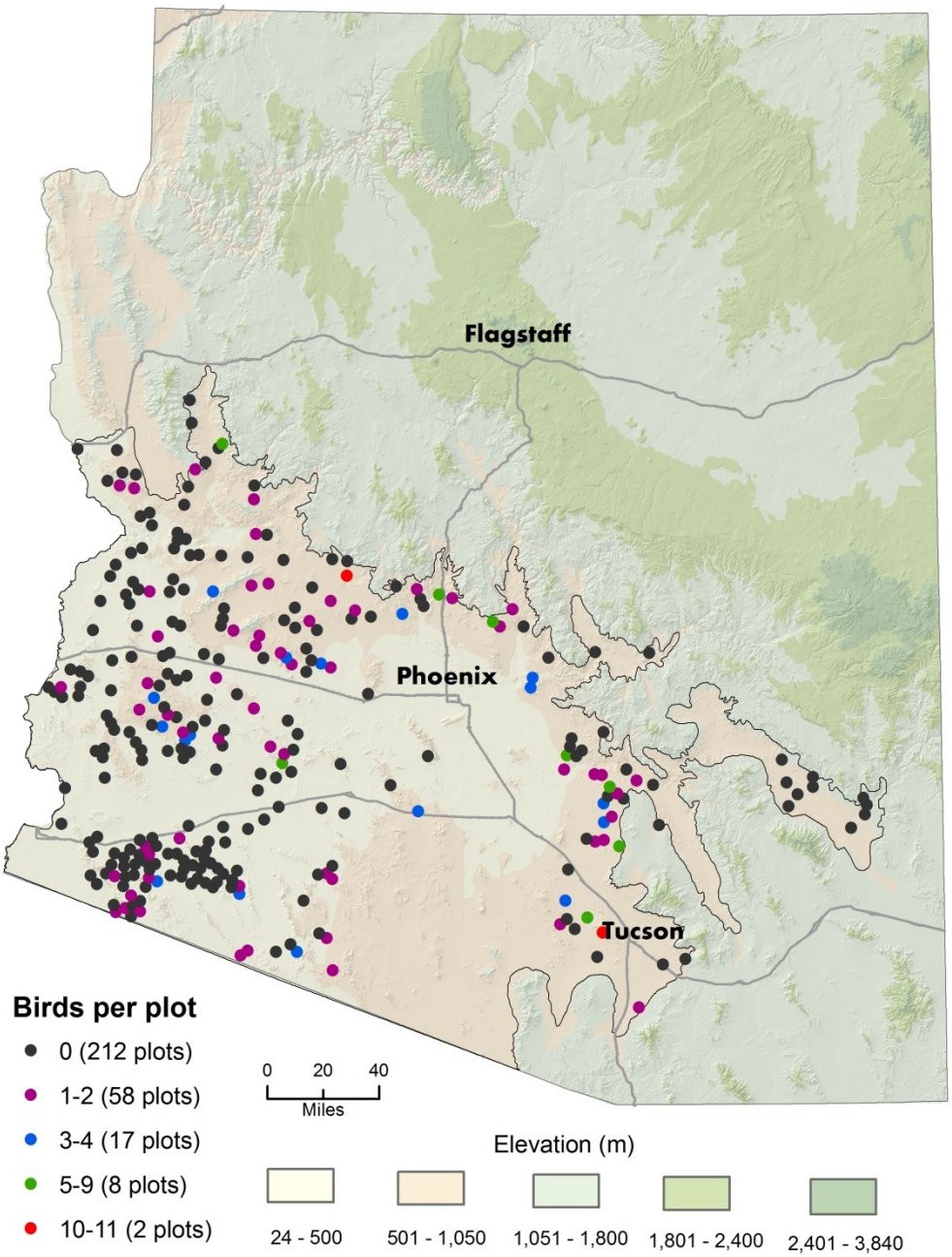
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	363	51	14.9	316,677	0.25
Upper	720	94	34.4	1,576,666	0.22
Both	1,083	145	27.2	1,885,159	0.23

Gila Woodpecker



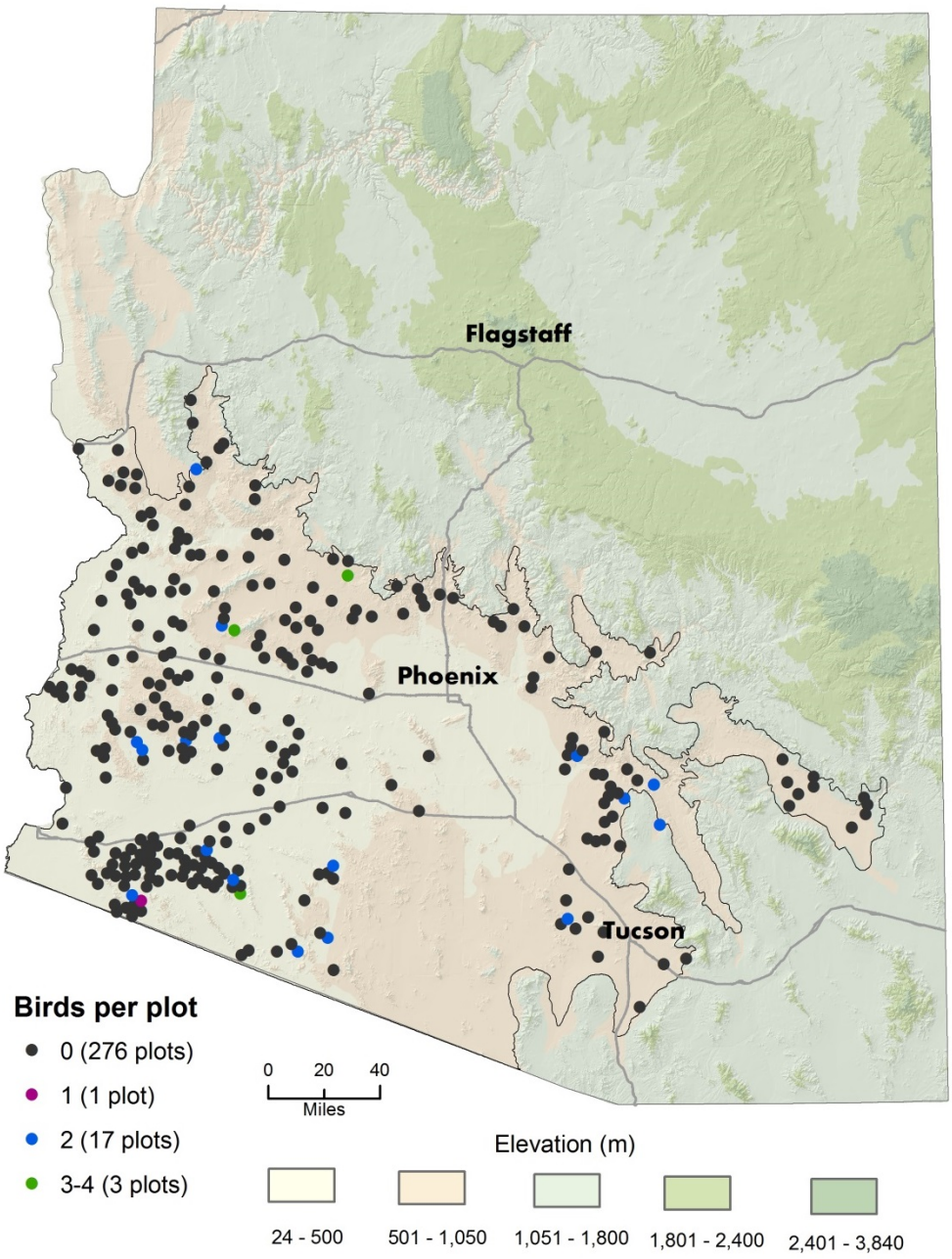
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	104	33	4.2	91,189	0.28
Upper	394	79	19.0	873,988	0.22
Both	498	112	13.9	958,884	0.22

Gilded Flicker



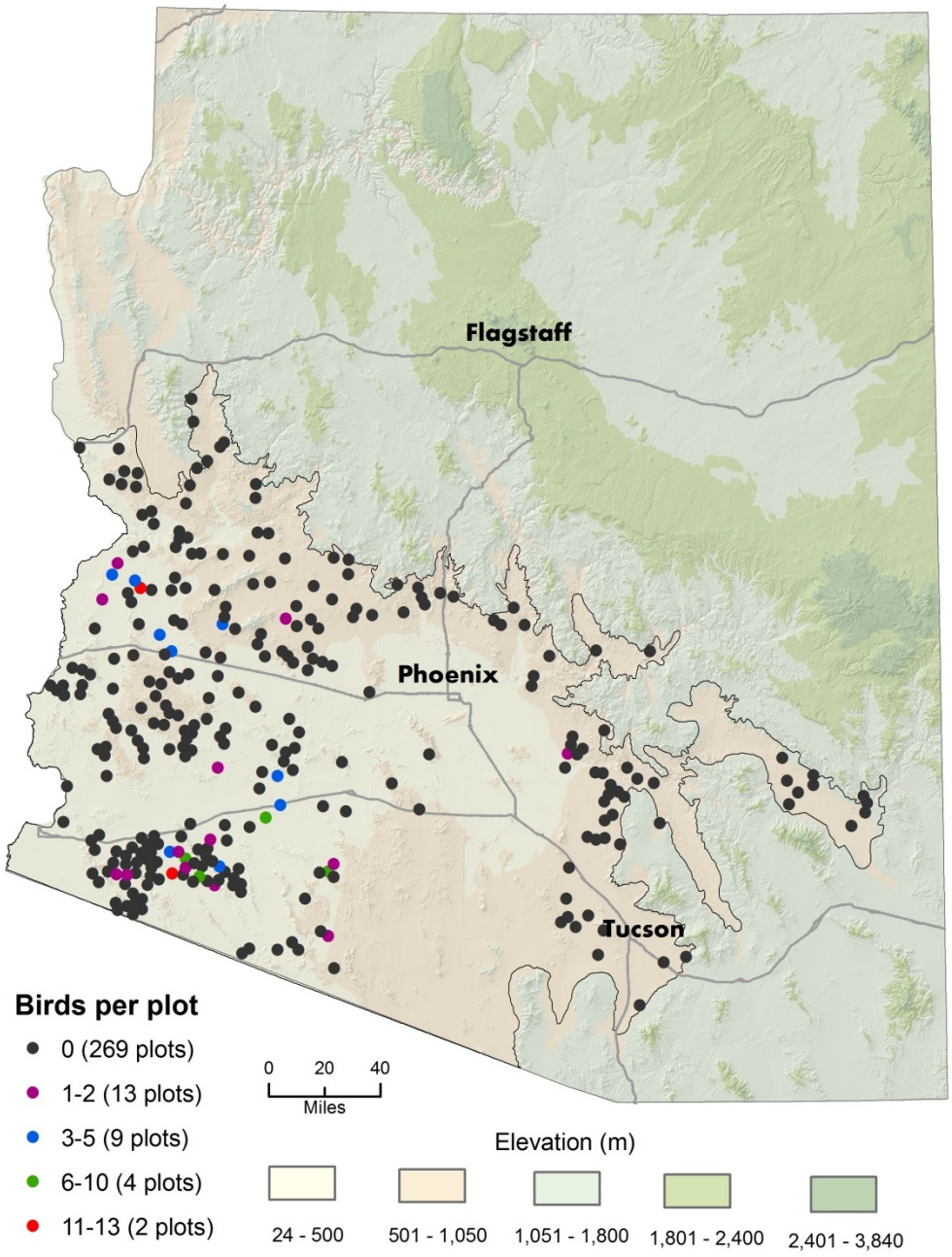
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	96	36	3.5	77,963	0.24
Upper	181	57	9.3	443,656	0.23
Both	277	93	7.5	518,947	0.23

Greater Roadrunner



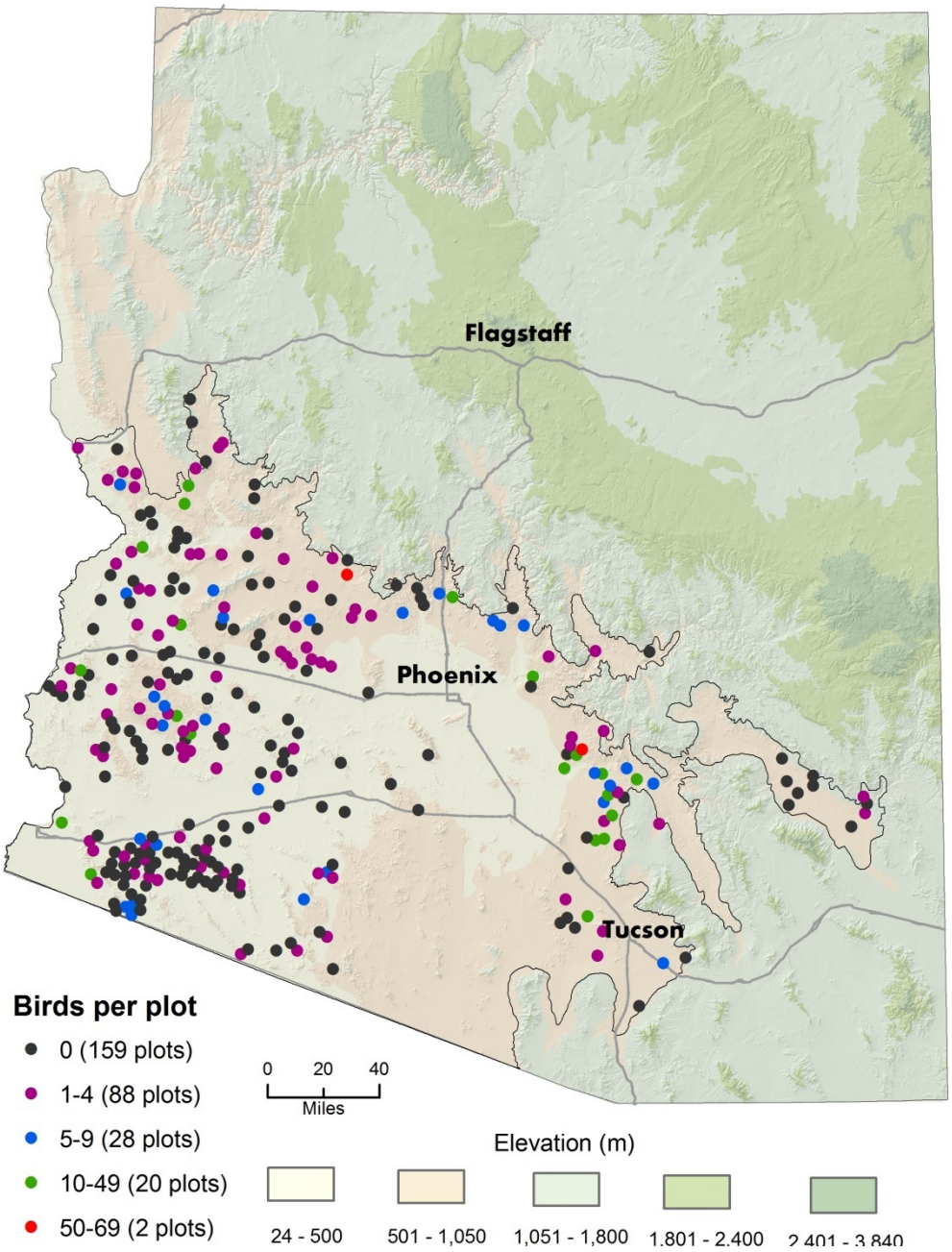
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	25	12	0.9	19,556	0.36
Upper	26	12	1.2	60,937	0.35
Both	51	24	1.2	80,364	0.31

Horned Lark



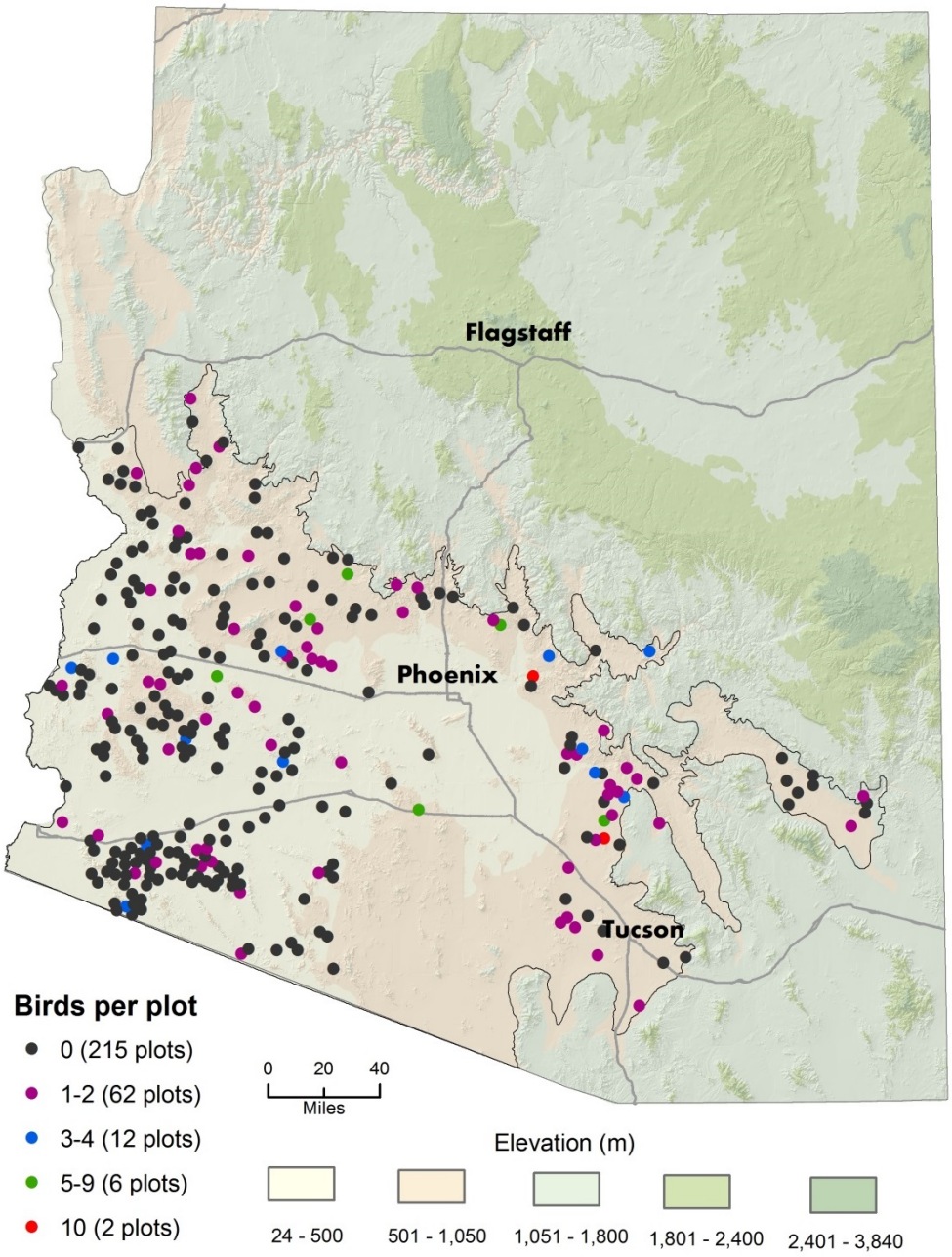
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	118	26	3.7	90,222	0.30
Upper	6	2	0.3	11,016	0.89
Both	124	28	1.5	102,898	0.29

House Finch



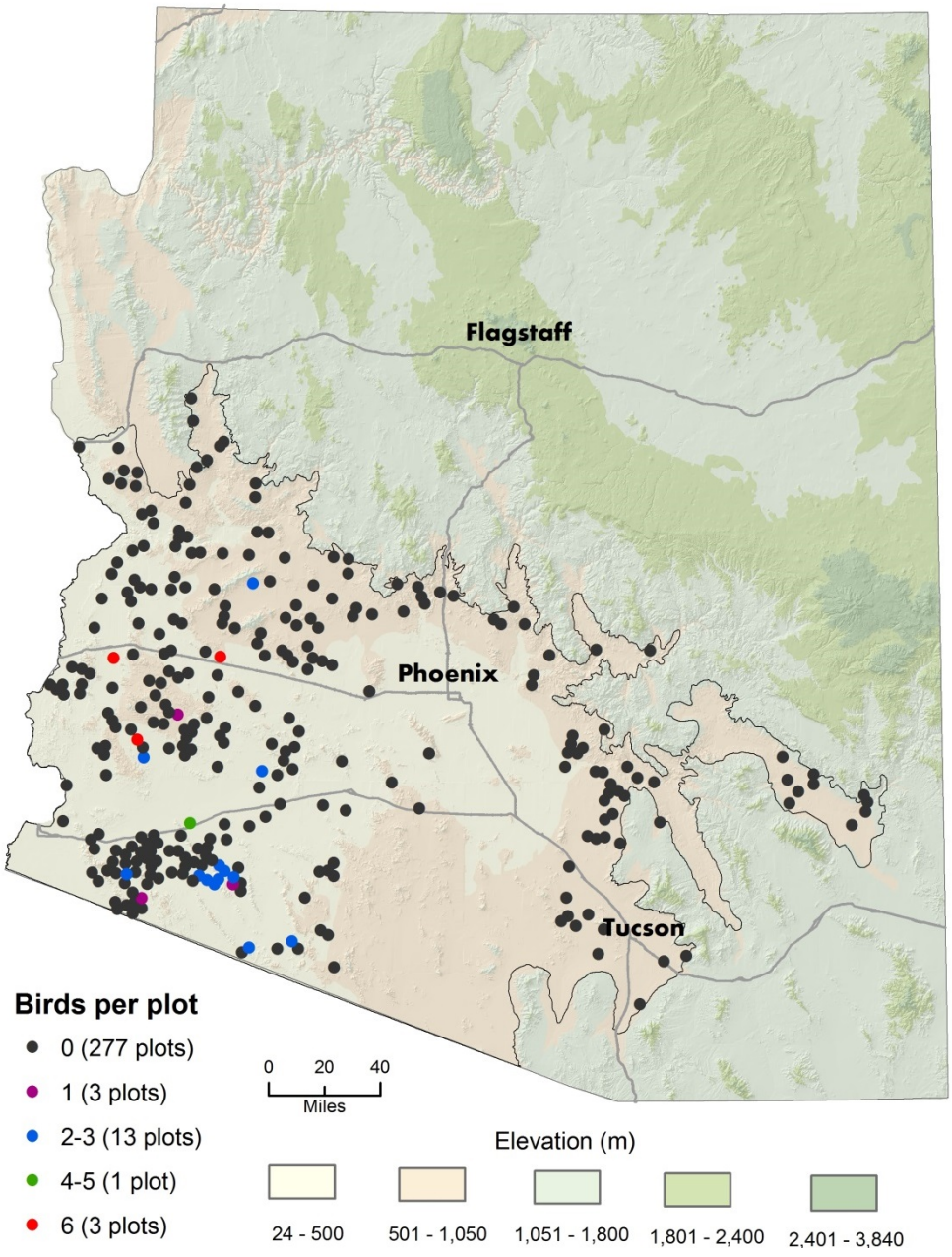
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	234	54	8.5	192,812	0.23
Upper	645	92	29.4	1,234,272	0.22
Both	879	146	20.5	1,418,759	0.23

Ladder-backed Woodpecker



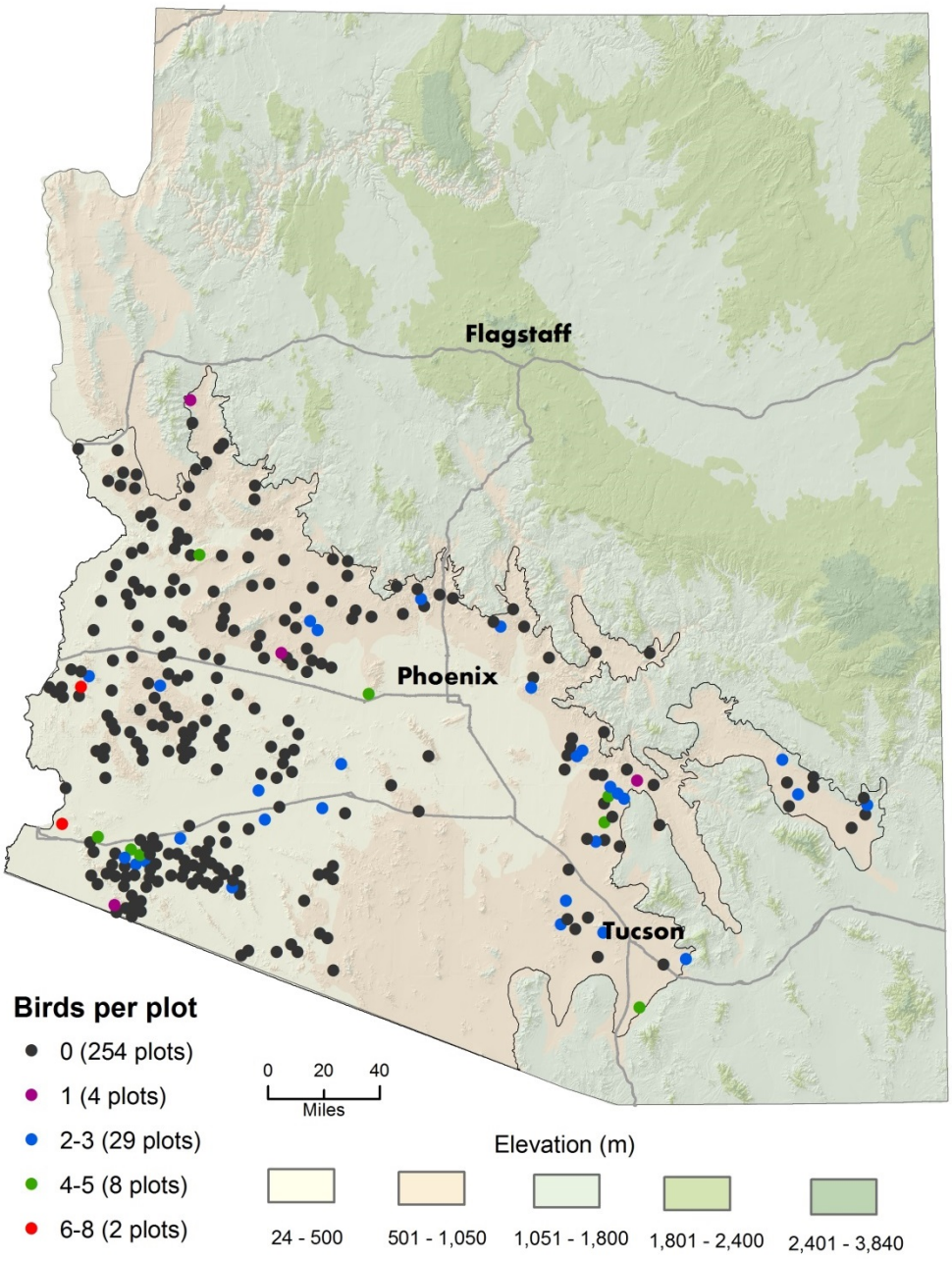
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	66	26	2.8	61,229	0.31
Upper	173	67	8.6	396,658	0.21
Both	239	93	6.6	455,207	0.22

Le Conte's Thrasher



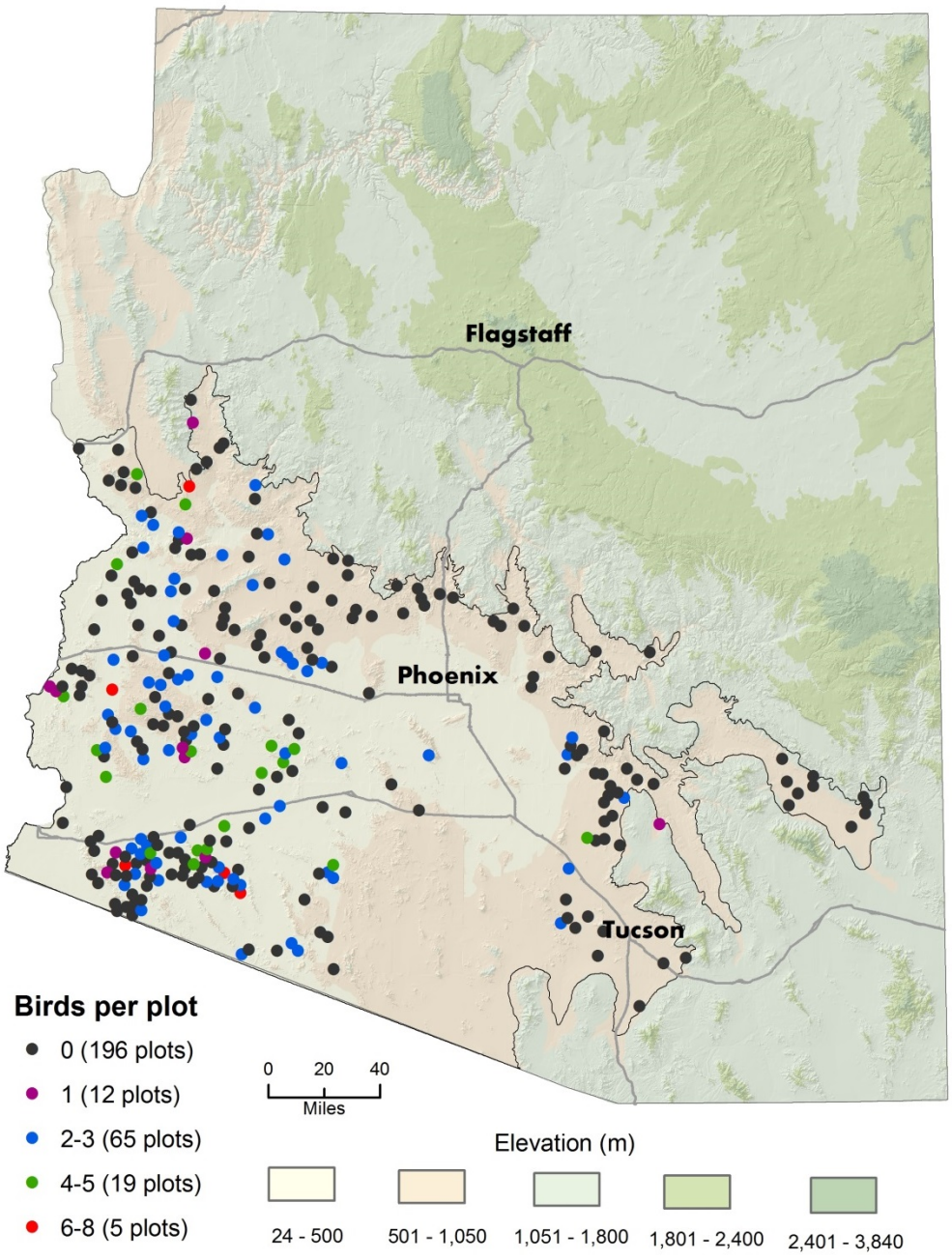
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	48	18	1.9	41,122	0.37
Upper	3	2	0.2	5,508	0.89
Both	51	20	0.7	48,402	0.33

Lesser Nighthawk



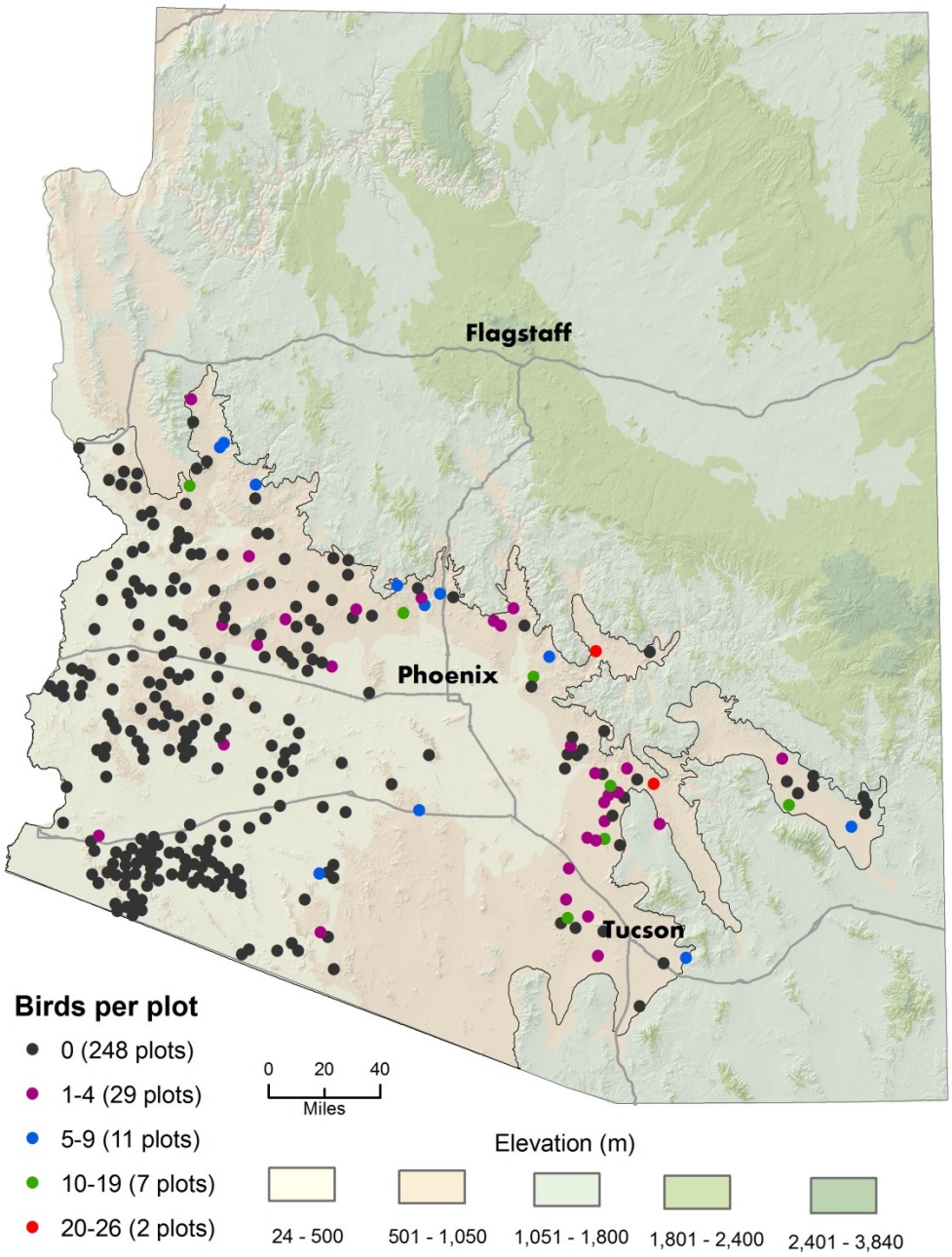
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	23	9	2.4	53,415	0.49
Upper	109	38	11.5	684,419	0.37
Both	132	47	10.6	732,879	0.42

Loggerhead Shrike



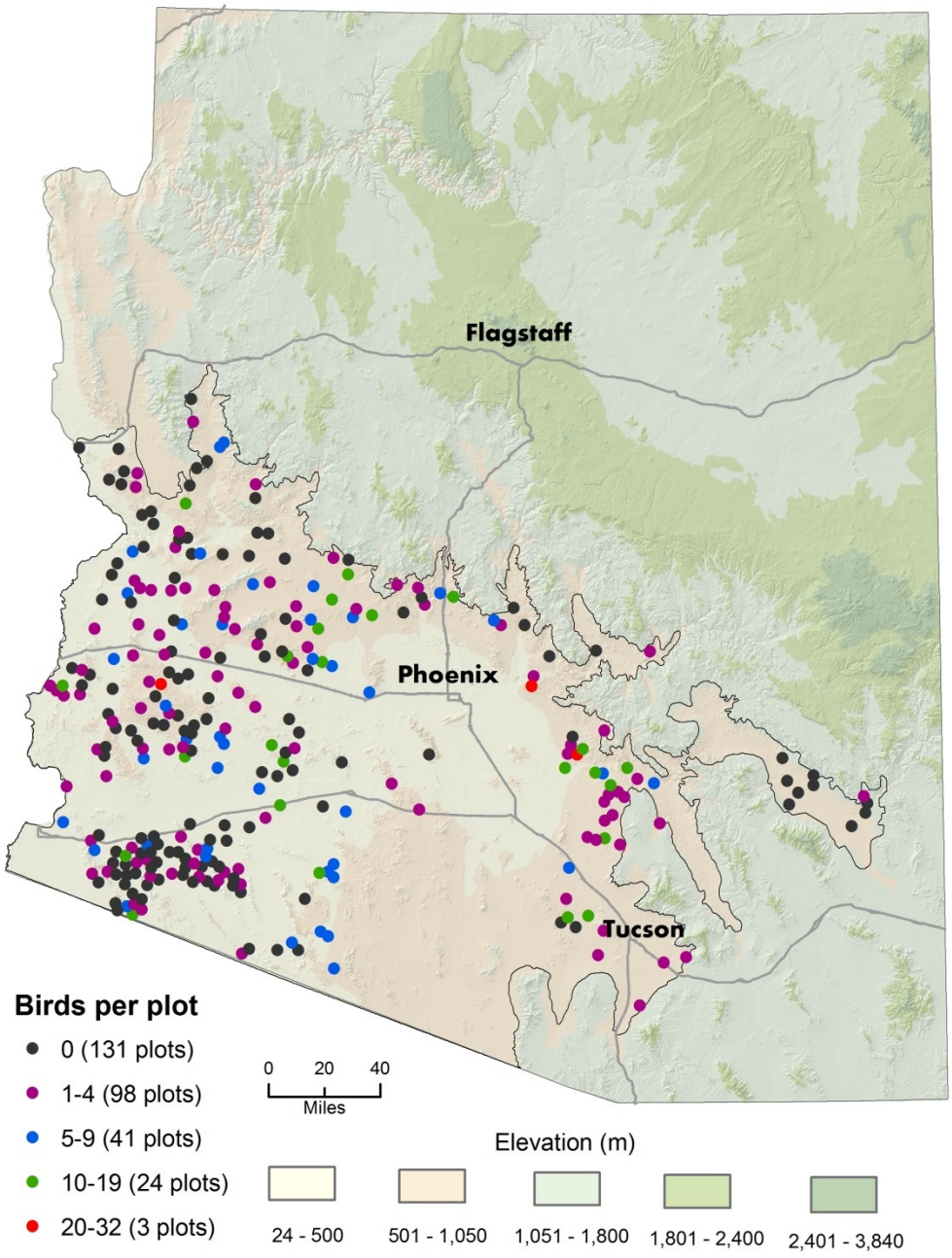
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	165	61	6.1	139,281	0.21
Upper	98	46	4.3	208,307	0.26
Both	263	107	5.0	348,331	0.21

Lucy's Warbler



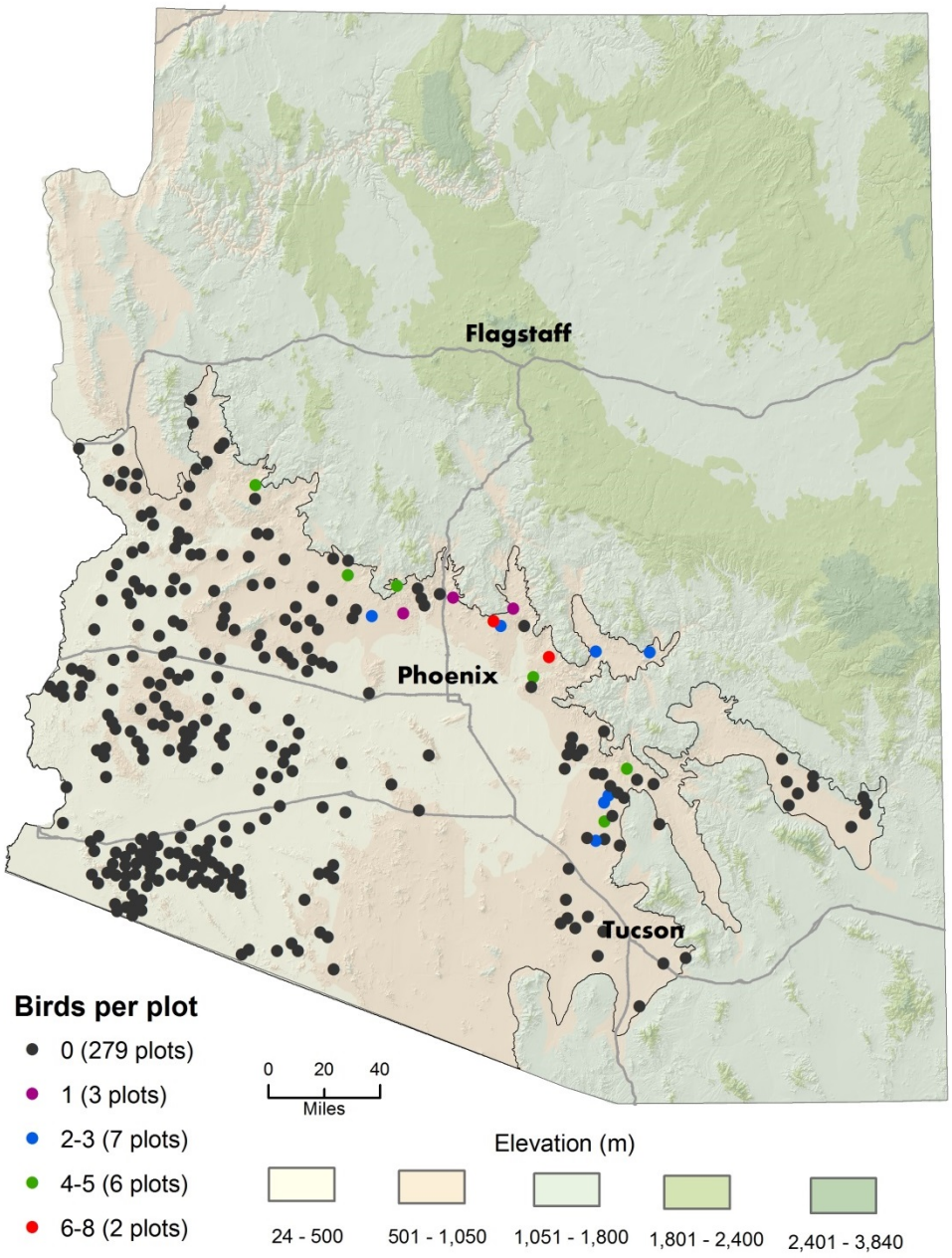
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	33	9	4.0	84,451	0.40
Upper	294	47	40.5	1,914,745	0.27
Both	327	56	28.7	1,983,448	0.28

Mourning Dove



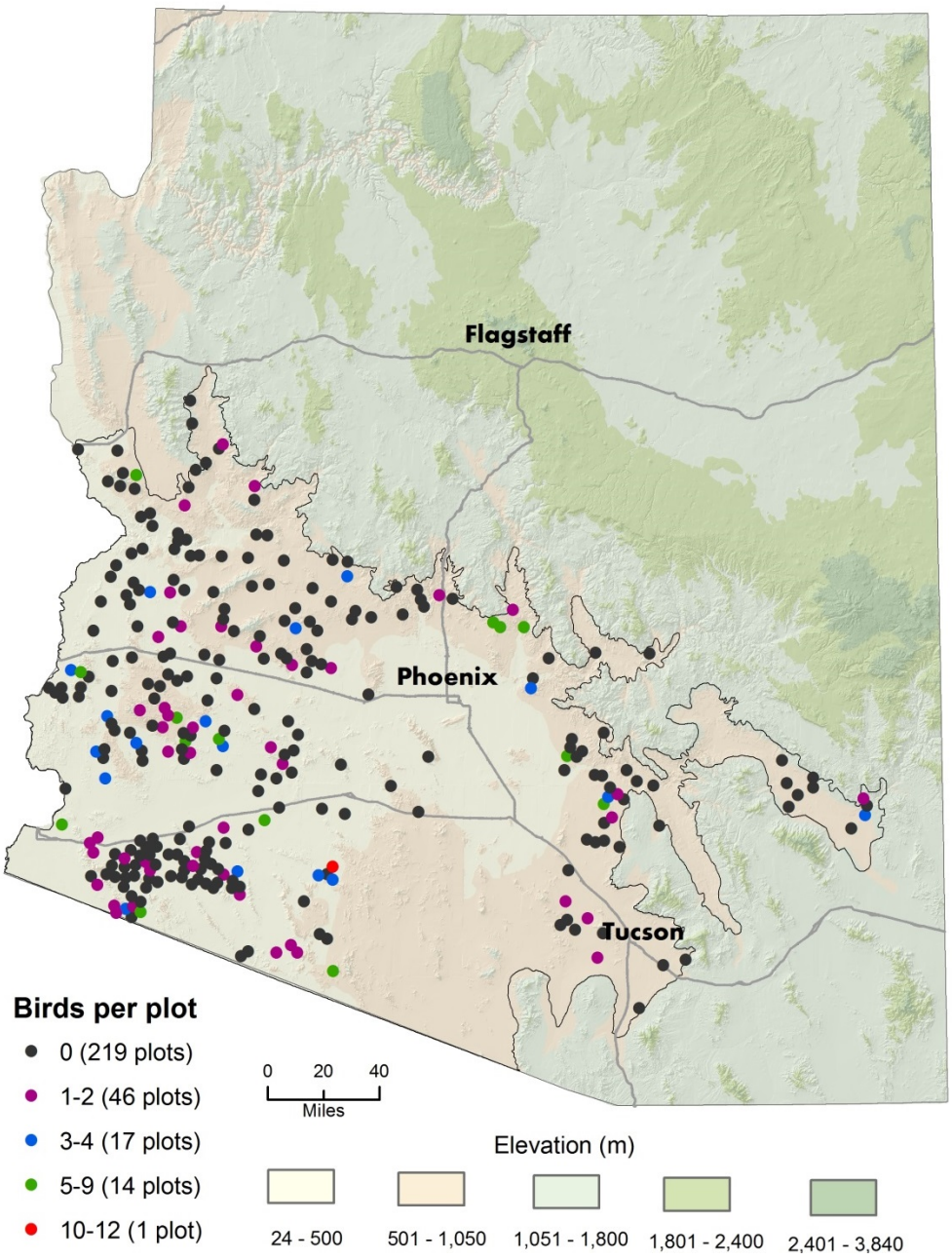
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	354	70	13.7	305,775	0.21
Upper	589	107	26.8	1,179,253	0.20
Both	943	177	21.4	1,479,862	0.20

Northern Cardinal



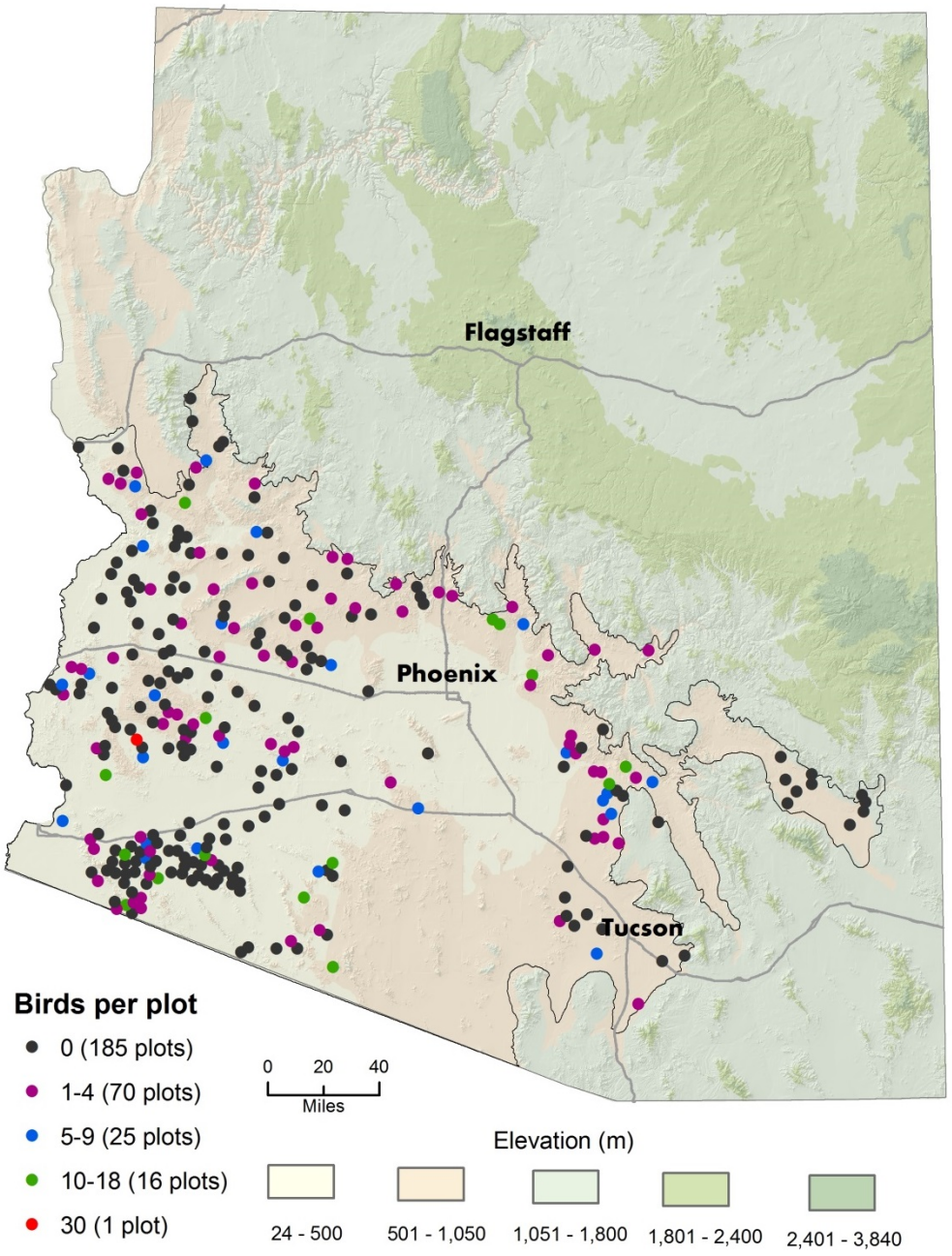
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	0	0	0.0	0	-
Upper	66	21	3.5	157,684	0.29
Both	66	21	2.3	157,684	0.31

Northern Mockingbird



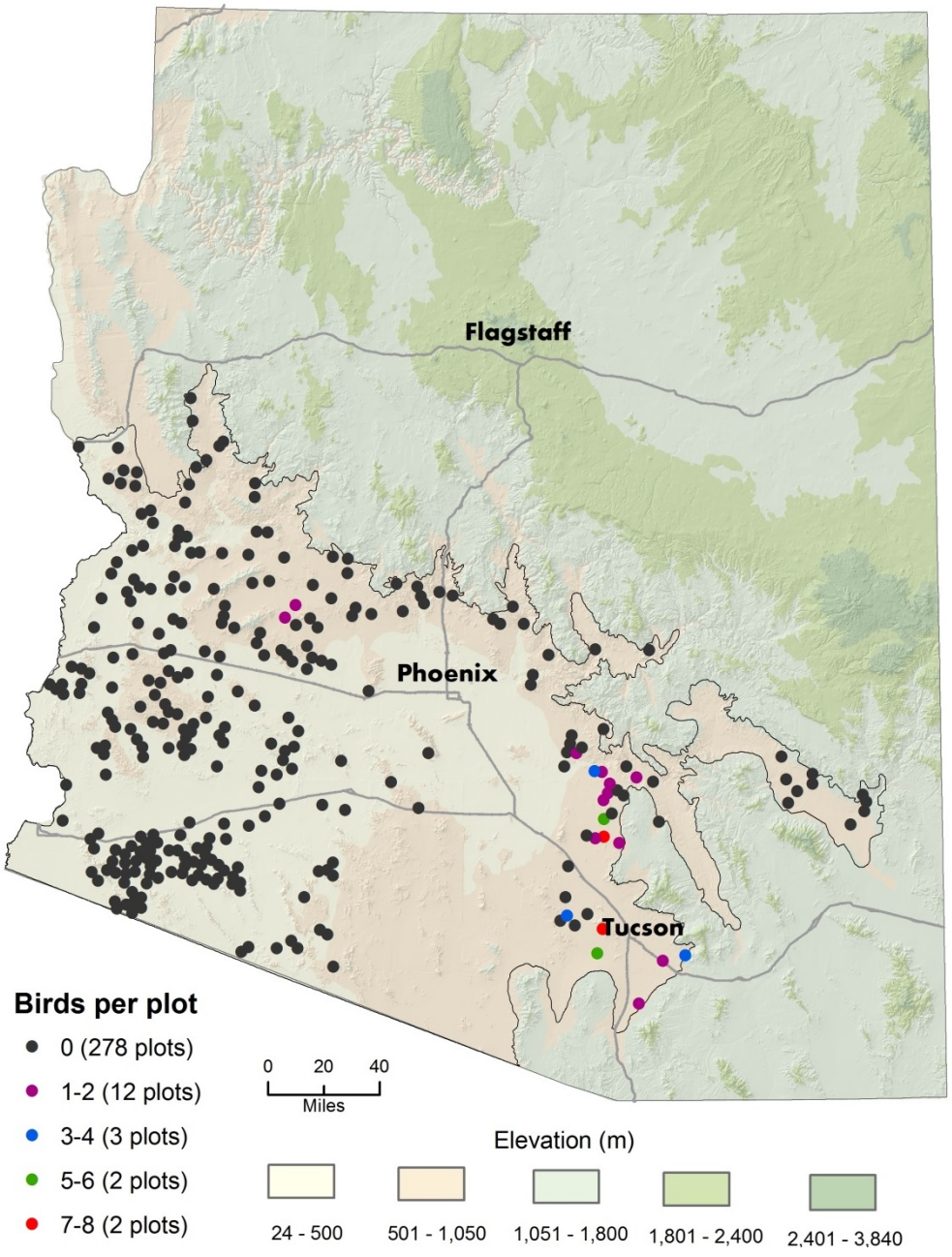
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	144	43	5.1	116,435	0.24
Upper	123	43	5.9	281,604	0.25
Both	267	86	5.7	397,711	0.22

Phainopepla



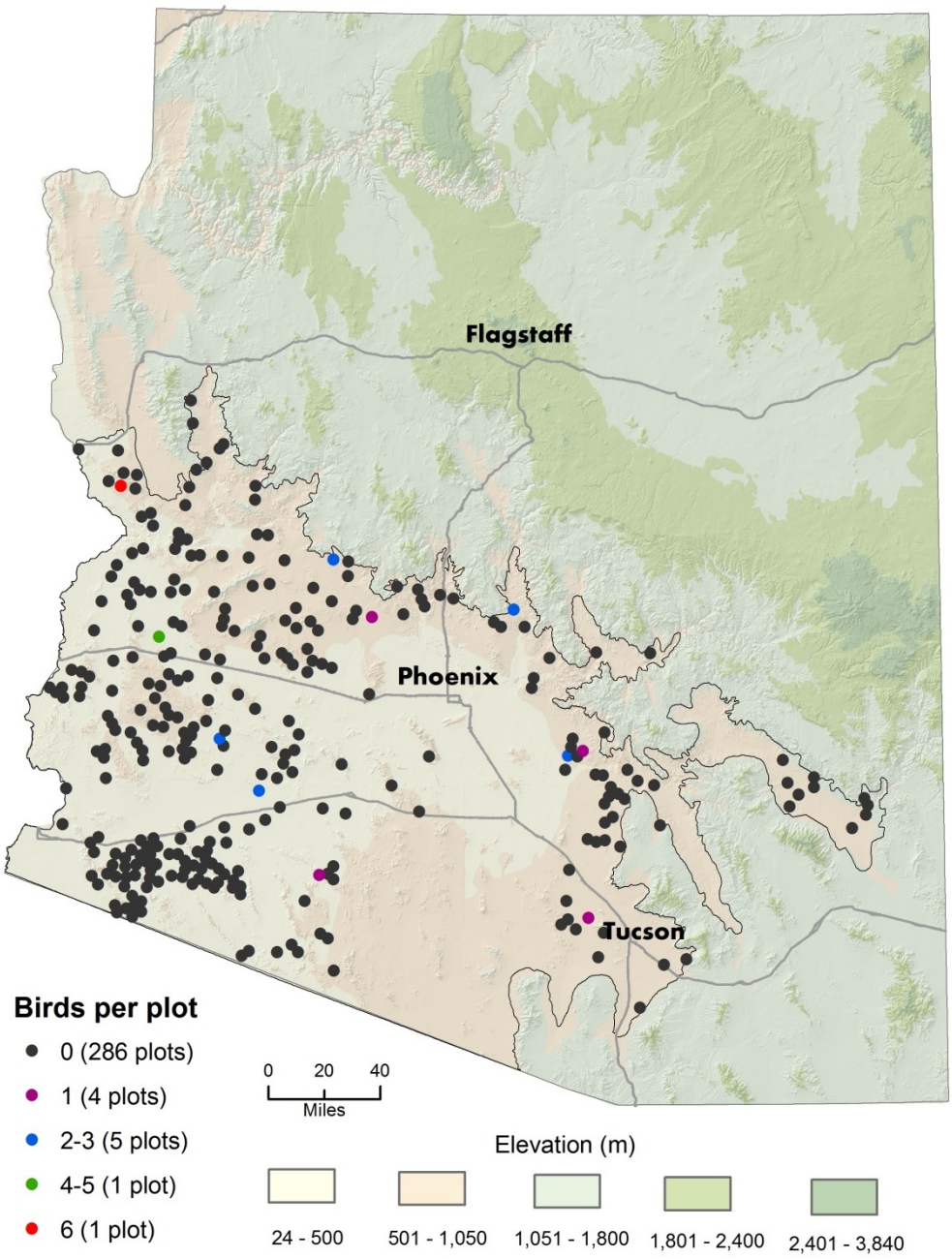
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	286	50	11.3	249,699	0.27
Upper	302	67	14.9	622,808	0.20
Both	588	117	12.6	871,309	0.22

Pyrrhuloxia



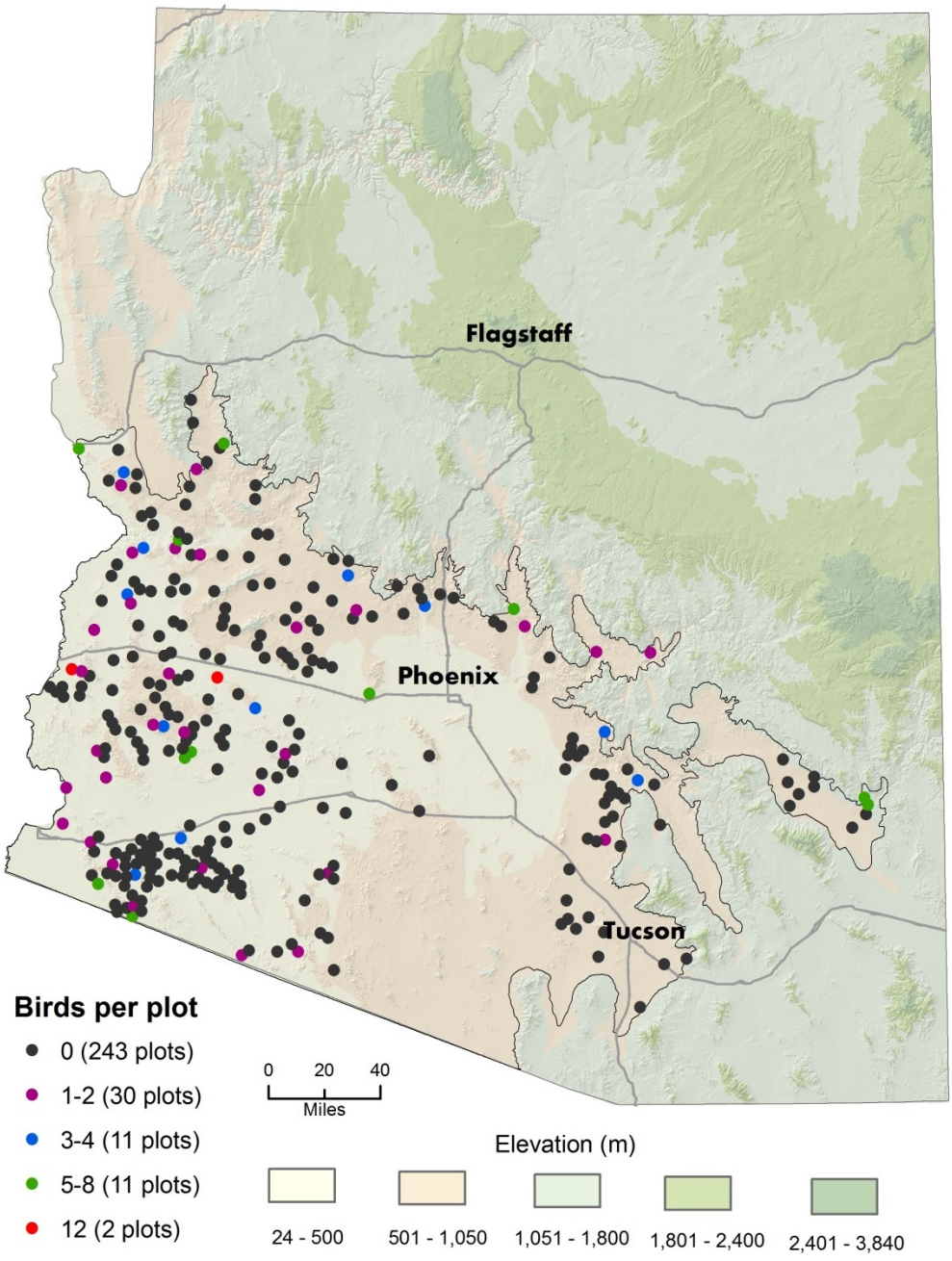
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	0	0	0.0	0	-
Upper	81	23	3.2	223,866	0.46
Both	81	23	3.2	223,866	0.46

Red-tailed Hawk



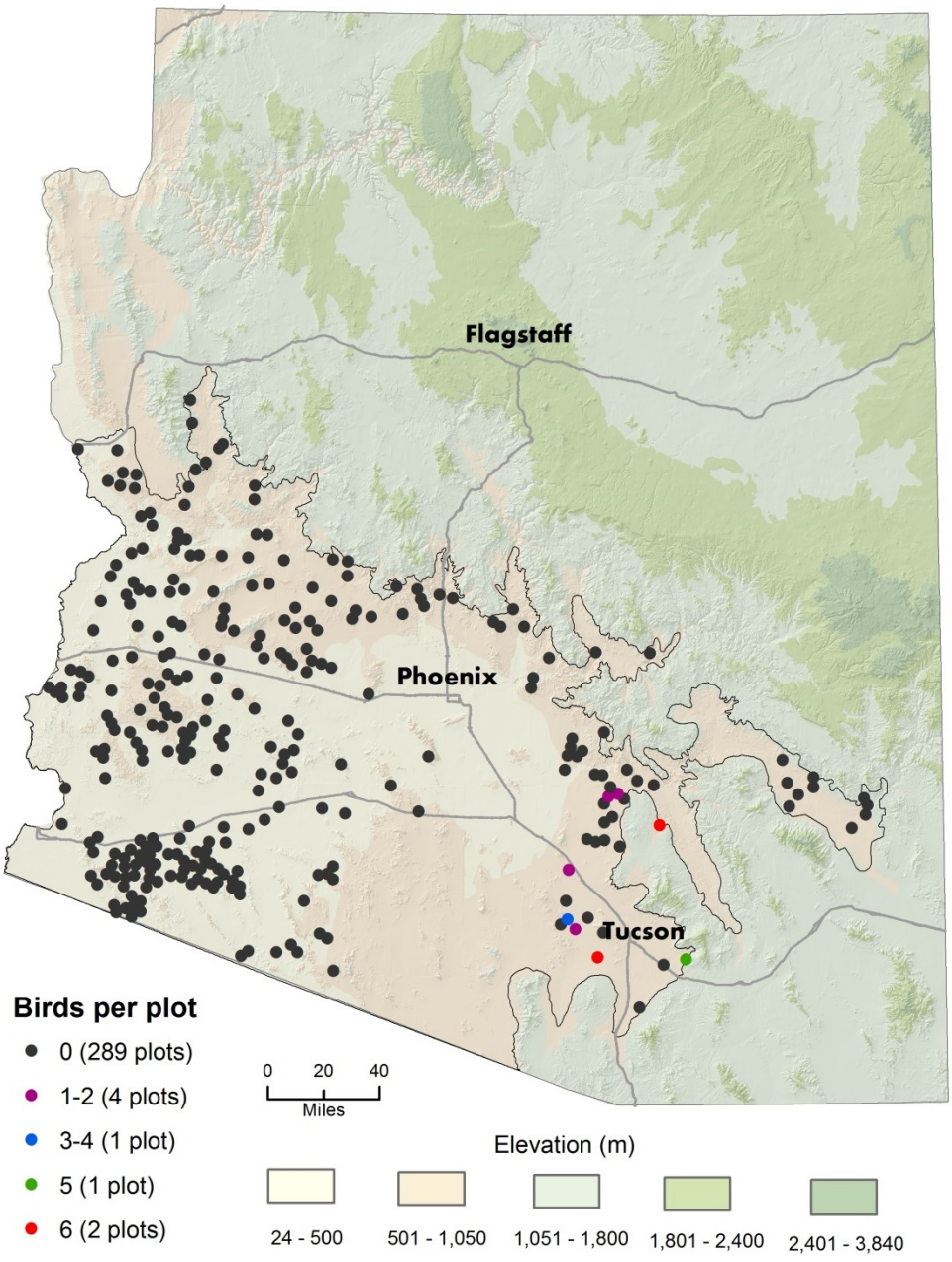
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	11	5	0.4	8,981	0.60
Upper	14	7	0.8	33,653	0.27
Both	25	12	0.6	42,458	0.47

Rock Wren



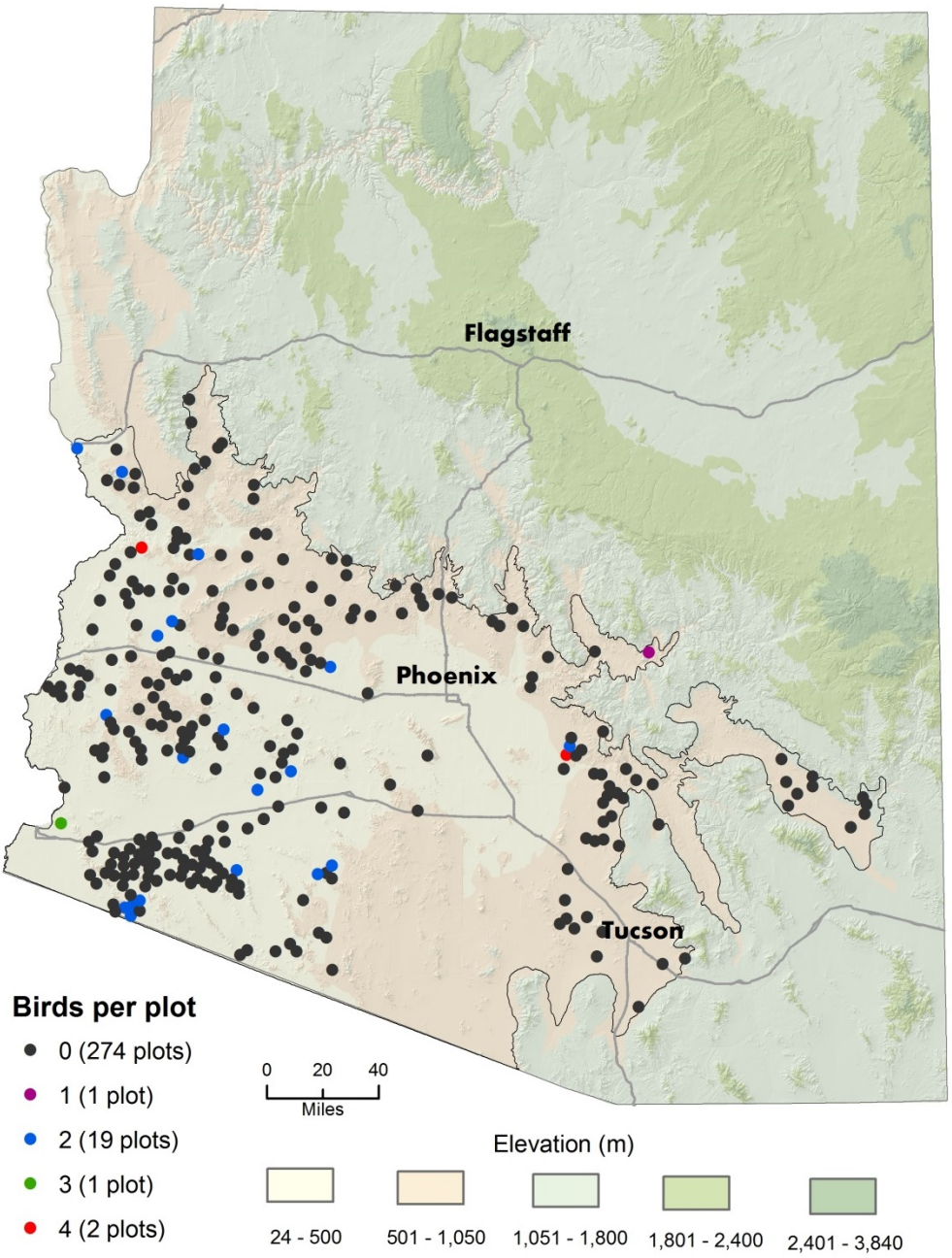
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	73	20	3.2	72,341	0.41
Upper	122	34	6.0	240,042	0.18
Both	195	54	4.5	311,007	0.25

Rufous-winged Sparrow



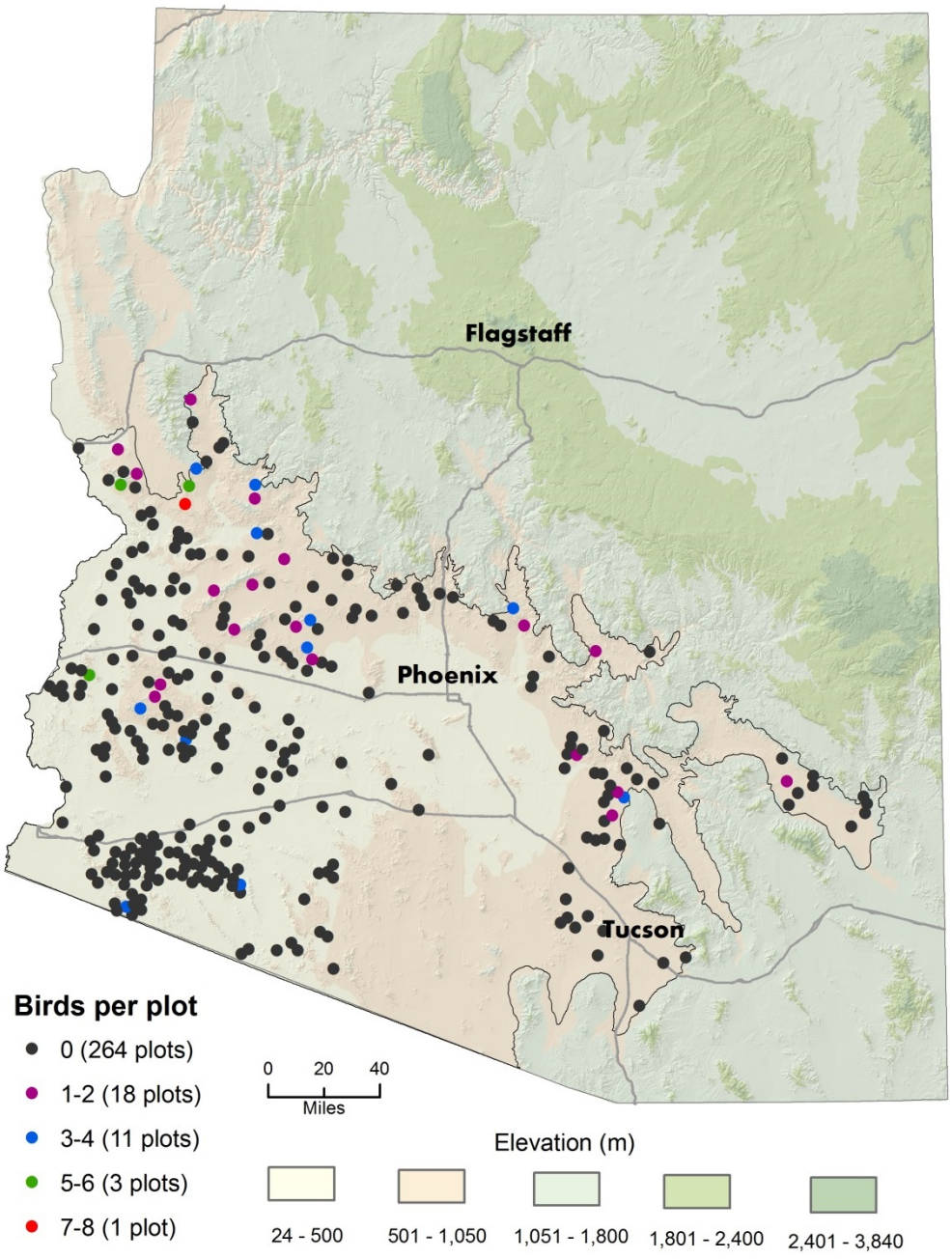
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	4	2	0.2	4,146	0.73
Upper	49	9	2.5	182,233	0.48
Both	53	11	2.7	184,874	0.49

Say's Phoebe



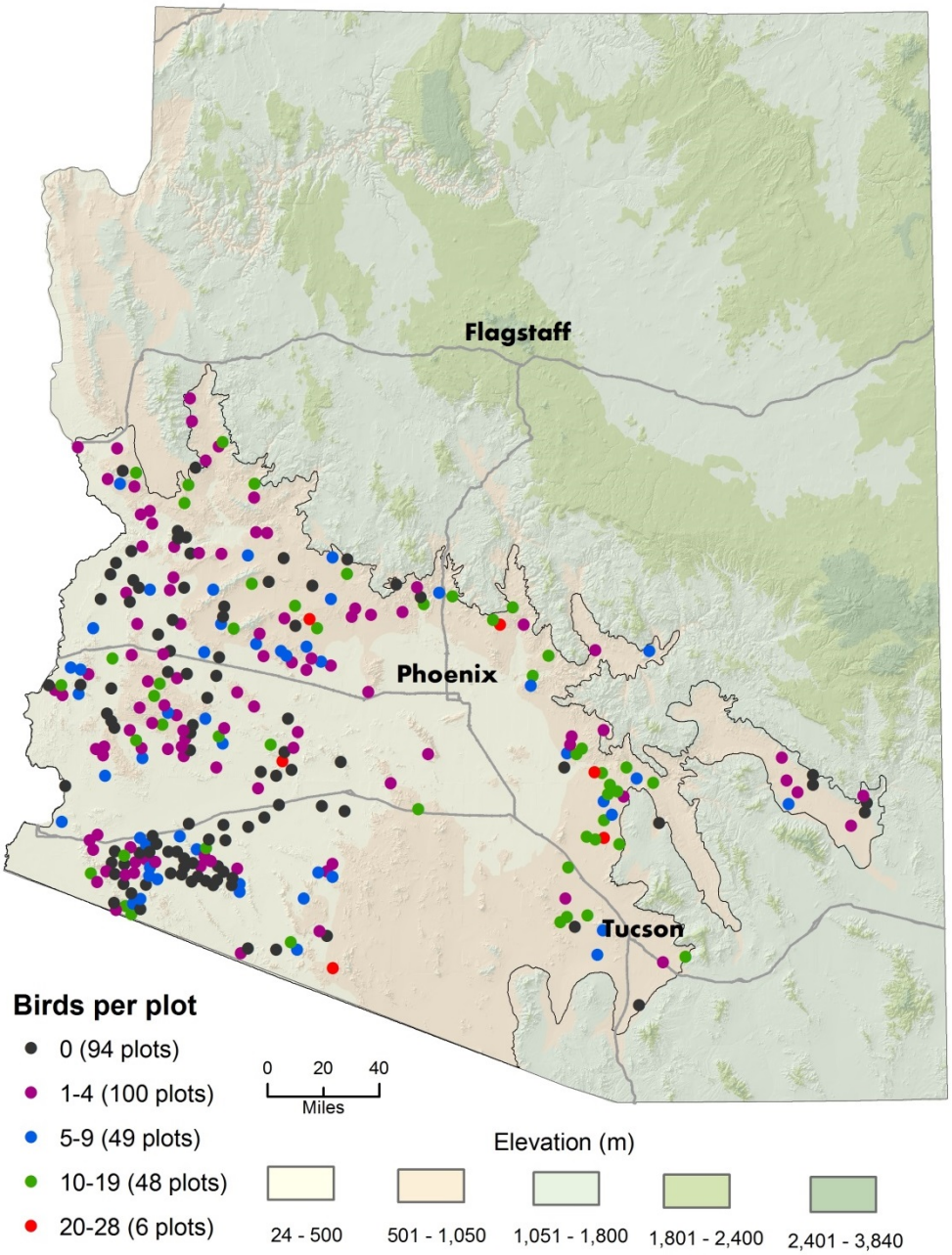
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	35	16	1.3	28,933	0.31
Upper	16	8	0.7	32,599	0.50
Both	51	24	0.9	61,758	0.29

Scott's Oriole



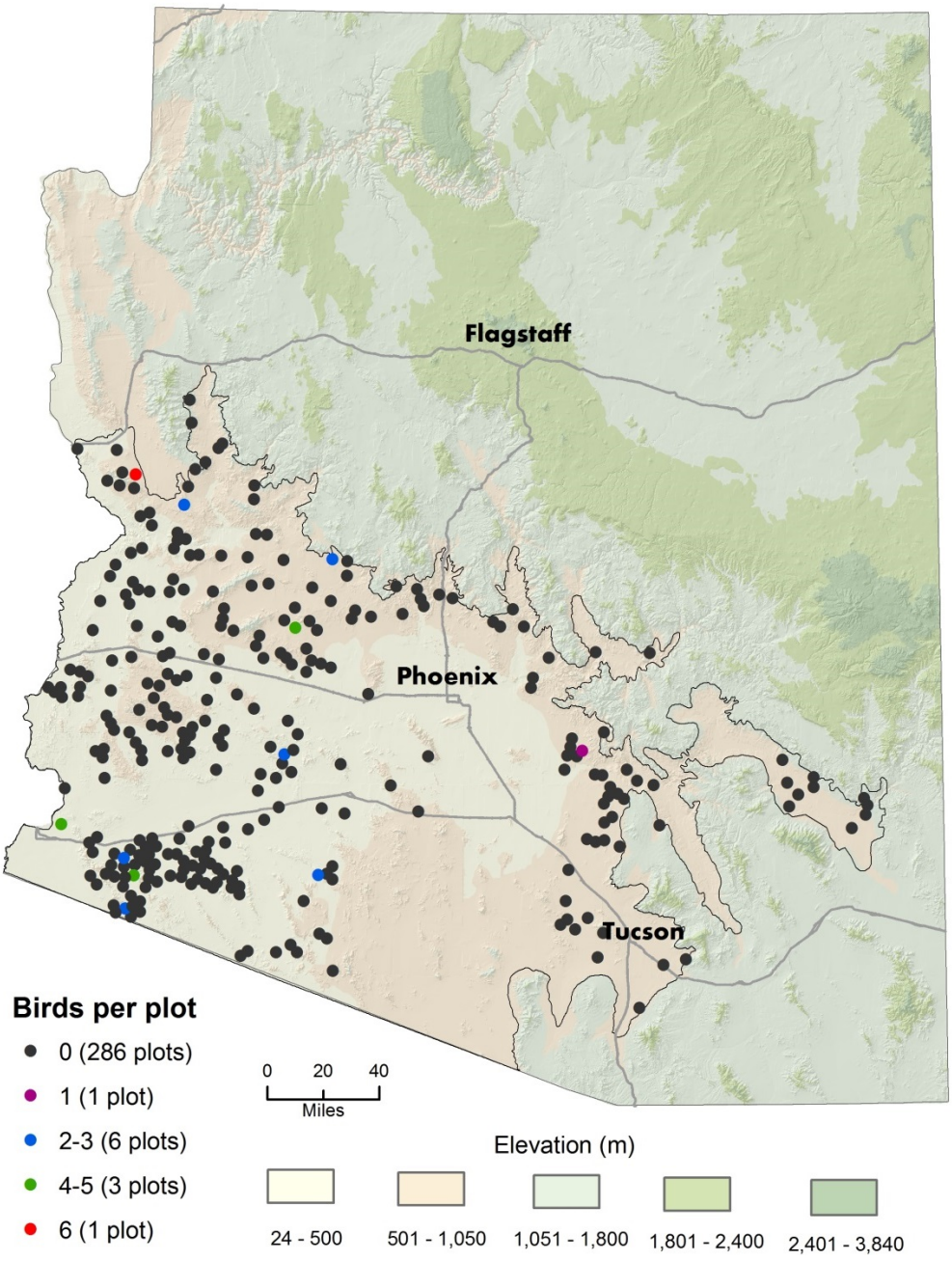
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	9	3	0.3	6,767	0.59
Upper	99	33	4.8	220,494	0.24
Both	108	36	3.3	225,290	0.27

Verdin



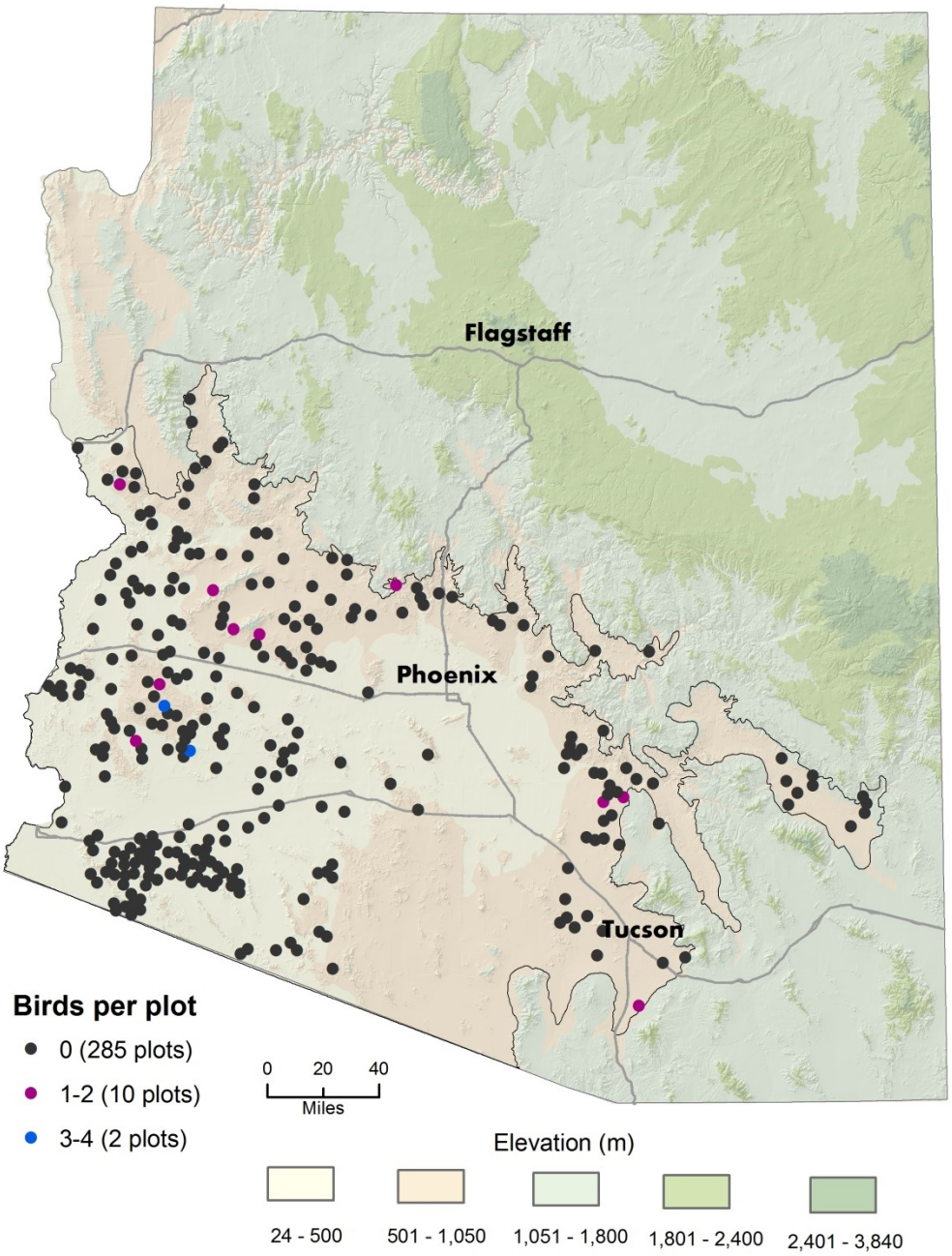
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	467	79	19.0	421,274	0.21
Upper	978	136	46.3	2,109,013	0.20
Both	1,445	215	36.4	2,518,847	0.20

Western Kingbird



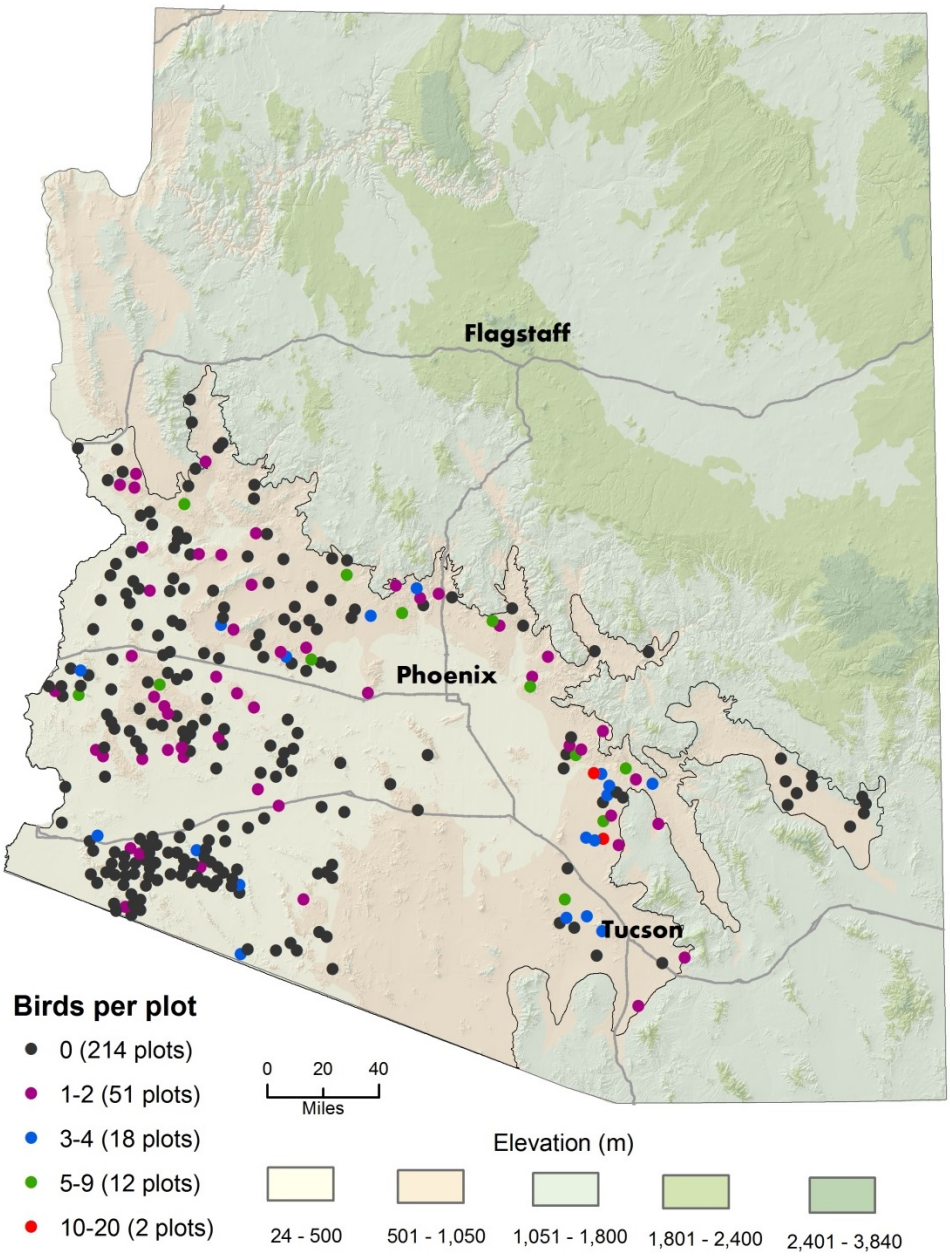
Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	11	4	0.4	9,707	0.67
Upper	22	8	1.0	47,149	0.42
Both	33	12	0.8	56,570	0.39

Western Screech-Owl



Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	4	2	0.3	5,802	0.75
Upper	24	10	1.1	44,601	0.36
Both	28	12	0.7	50,054	0.35

White-winged Dove



Region	N of birds recorded	N of plots	Density (birds/km^2)	Population size	CV
Lower	34	15	4.3	90,557	0.31
Upper	283	76	35.6	1,704,405	0.23
Both	317	91	25.7	1,780,909	0.24

APPENDIX D: DOUBLE INTENSIVE SURVEY DATA COMPARISONS NOTING DIFFERENCES IN SPECIES ESTIMATES PER PLOT BY INDEPENDENT SURVEYORS

Year	Plot	Species	Surveyor				
			1	2	3	4	5
2013	2249	Ash-throated Flycatcher	6	14	-	-	-
2013	2249	Black-tailed Gnatcatcher	10	10	-	-	-
2013	2249	Black-throated Sparrow	4	2	-	-	-
2013	2249	Crissal Thrasher	2	0	-	-	-
2013	2249	Gambel's Quail	0	4	-	-	-
2013	2249	Gila Woodpecker	2	0	-	-	-
2013	2249	Greater Roadrunner	4	2	-	-	-
2013	2249	Horned Lark	2	0	-	-	-
2013	2249	Loggerhead Shrike	2	4	-	-	-
2013	2249	Lucy's Warbler	8	8	-	-	-
2013	2249	Mourning Dove	4	8	-	-	-
2013	2249	Phainopepla	0	2	-	-	-
2013	2249	Verdin	2	8	-	-	-
2013	2249	Western Kingbird	2	0	-	-	-
2013	2249	White-winged Dove	2	8	-	-	-
2013	35860	Ash-throated Flycatcher	6	8	-	-	-
2013	35860	Black-tailed Gnatcatcher	14	11	-	-	-
2013	35860	Black-throated Sparrow	20	23	-	-	-
2013	35860	Brown-crested Flycatcher	2	2	-	-	-
2013	35860	Cactus Wren	14	22	-	-	-
2013	35860	Canyon Towhee	10	12	-	-	-
2013	35860	Crissal Thrasher	2	0	-	-	-
2013	35860	Curve-billed Thrasher	8	19	-	-	-
2013	35860	Gambel's Quail	13	20	-	-	-
2013	35860	Gila Woodpecker	0	2	-	-	-
2013	35860	Gilded Flicker	2	0	-	-	-
2013	35860	Greater Roadrunner	0	4	-	-	-
2013	35860	House Finch	4	14	-	-	-
2013	35860	Ladder-backed Woodpecker	4	4	-	-	-
2013	35860	Lesser Nighthawk	4	11	-	-	-
2013	35860	Lucy's Warbler	4	4	-	-	-
2013	35860	Mourning Dove	5	4	-	-	-
2013	35860	Northern Cardinal	0	2	-	-	-
2013	35860	Say's Phoebe	2	0	-	-	-
2013	35860	Scott's Oriole	0	4	-	-	-
2013	35860	Verdin	12	13	-	-	-
2013	35860	White-winged Dove	0	4	-	-	-
2013	4289	American Kestrel	-	2	-	4	-
2013	4289	Ash-throated Flycatcher	-	5	-	6	-
2013	4289	Black-tailed Gnatcatcher	-	18	-	14	-
2013	4289	Black-throated Sparrow	-	14	-	12	-
2013	4289	Brown-crested Flycatcher	-	14	-	20	-
2013	4289	Cactus Wren	-	15	-	17	-
2013	4289	Canyon Towhee	-	8	-	6	-
2013	4289	Curve-billed Thrasher	-	18	-	24	-
2013	4289	Gambel's Quail	-	13	-	22	-
2013	4289	Gila Woodpecker	-	18	-	21	-

2013	4289	Gilded Flicker	-	8	-	7.5	-
2013	4289	House Finch	-	6	-	11	-
2013	4289	Ladder-backed Woodpecker	-	5	-	6	-
2013	4289	Lesser Nighthawk	-	6	-	8	-
2013	4289	Mourning Dove	-	8	-	6	-
2013	4289	Northern Cardinal	-	0	-	8	-
2013	4289	Purple Martin	-	10	-	19	-
2013	4289	Pyrrhuloxia	-	12	-	13	-
2013	4289	Verdin	-	26	-	51.5	-
2013	4289	White-winged Dove	-	32	-	42	-
2013	92197	Ash-throated Flycatcher	-	-	-	16	6
2013	92197	Black-tailed Gnatcatcher	-	-	-	9	4
2013	92197	Black-throated Sparrow	-	-	-	13	8
2013	92197	Brown-crested Flycatcher	-	-	-	6	0
2013	92197	Cactus Wren	-	-	-	21	8
2013	92197	Canyon Towhee	-	-	-	39	8
2013	92197	Common Poorwill	-	-	-	0	2
2013	92197	Curve-billed Thrasher	-	-	-	21	8
2013	92197	Elf Owl	-	-	-	4	0
2013	92197	Gambel's Quail	-	-	-	12	14
2013	92197	Gila Woodpecker	-	-	-	2	4
2013	92197	Gilded Flicker	-	-	-	9	2
2013	92197	House Finch	-	-	-	23	12
2013	92197	Ladder-backed Woodpecker	-	-	-	6	2
2013	92197	Lucy's Warbler	-	-	-	2	6
2013	92197	Mourning Dove	-	-	-	18	4
2013	92197	Northern Mockingbird	-	-	-	2	2
2013	92197	Phainopepla	-	-	-	4	2
2013	92197	Red-tailed Hawk	-	-	-	1	0
2013	92197	Rock Wren	-	-	-	1	0
2013	92197	Say's Phoebe	-	-	-	1	0
2013	92197	Scott's Oriole	-	-	-	1	0
2013	92197	Verdin	-	-	-	22	12
2013	92197	White-winged Dove	-	-	-	10	2
2014	46689	Ash-throated Flycatcher	2	1	-	-	-
2014	46689	Black-tailed Gnatcatcher	3	3	-	-	-
2014	46689	Black-throated Sparrow	10	6	-	-	-
2014	46689	Crissal Thrasher	0	2	-	-	-
2014	46689	Lesser Nighthawk	1	2	-	-	-
2014	46689	Lucy's Warbler	5	3	-	-	-
2014	46689	Mourning Dove	2	0	-	-	-
2014	46689	Verdin	2	2	-	-	-
2014	81232	Ash-throated Flycatcher	2	-	2	-	-
2014	81232	Black-tailed Gnatcatcher	2	-	4	-	-
2014	81232	Black-throated Sparrow	4	-	6	-	-
2014	81232	Crissal Thrasher	2	-	3	-	-
2014	81232	House Finch	0	-	1	-	-
2014	81232	Lesser Nighthawk	0	-	2	-	-
2014	81232	Lucy's Warbler	2	-	2	-	-
2014	81232	Northern Mockingbird	0	-	2	-	-
2014	81232	Verdin	2	-	2	-	-
2014	8177	Ash-throated Flycatcher	4	-	4	-	-
2014	8177	Black-tailed Gnatcatcher	5	-	9	-	-

2014	8177	Black-throated Sparrow	3	-	6	-	-
2014	8177	Crissal Thrasher	1	-	4	-	-
2014	8177	Gambel's Quail	0	-	5	-	-
2014	8177	House Finch	0	-	2	-	-
2014	8177	Ladder-backed Woodpecker	3	-	2	-	-
2014	8177	Lucy's Warbler	10	-	13	-	-
2014	8177	Mourning Dove	5	-	13	-	-
2014	8177	Verdin	6	-	8	-	-
2014	8177	White-winged Dove	2	-	4	-	-
2014	90921	Ash-throated Flycatcher	-	0	2	-	-
2014	90921	Black-tailed Gnatcatcher	-	4	5	-	-
2014	90921	Black-throated Sparrow	-	4	9	-	-
2014	90921	Cactus Wren	-	5	6	-	-
2014	90921	House Finch	-	3	5	-	-
2014	90921	Loggerhead Shrike	-	0	2	-	-
2014	90921	Mourning Dove	-	2	4	-	-
2014	90921	Rock Wren	-	1	5	-	-
2014	90921	Verdin	-	2	2	-	-
2014	90921	Western Screech-Owl	-	0	2	-	-
2014	90921	White-winged Dove	-	0	2	-	-