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Developing Habitat Models and Monitoring Techniques for Nine Bird Species of Clark County

Report of a 6-Year Inventory and Monitoring Project on Landbirds of Clark County, Nevada

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Abstract

This six-year study (2008 – 2013) was funded by the Clark County Multi-Species Habitat Conservation Plan (MSHCP) and followed nine years of previous bird surveys and monitoring of landbirds in Clark County, which were done for the purpose of better informing land managers of the status and conservation needs of birds breeding in Clark County. In this report, we summarize the results of our attempts to estimate population sizes, habitat-specific densities, habitat use patterns, actual and predicted distributions, and predicted densities in spatial models of nine focal species of the Clark County. For a full Clark County species list from all breeding season surveys we have conducted since 1998 and for a better understanding of the known focal species distributions, we also include these earlier survey data in comprehensive species list and distribution maps. The nine focal species included six MSHCP-covered species, the Southwestern Willow Flycatcher (*Empidonax traillii extimus*), Blue Grosbeak (*Passerina caerulea*), Phainopepla (*Phainopepla nitens*), Summer Tanager (*Prianga rubra*), Vermilion Flycatcher (*Pyrocephalus rubinus*), and Arizona's Bell's Vireo (*Vireo bellii arizonae*), and three MSHCP-evaluation species, the Bendire's Thrasher (*Toxostoma bendirei*), Le Conte's Thrasher (*Toxostoma lecontei*), and Gray Vireo (*Vireo vicinior*). Over the six years of this study, we conducted 1,045 visits to 316 mostly randomly-selected 10-point point count transects, the first round of which were selected from a habitat-stratified sampling scheme in 2002. We restratified the sampling area in 2012, when new and improved spatial vegetation data became available, and reselected random transects based on these layers. We further surveyed 35 randomly-selected plots using intensive area searches in different habitat types to allow for detectability corrections to density and population estimates. During the 10-minute point counts, we also added methods to distinguish between different time intervals during the count that would allow for removal models to be applied, which is a different method for estimating species detectabilities. With these methods, we generated population size estimates for Clark County for each of the nine focal species, with mixed results. We found that 95% confidence intervals were generally wide for the focal species, meaning that the population estimates are tenuous. This was particularly true for year-to-year population estimates of the rarer focal species and for habitat strata that had few detections.

We also compiled all survey records from 15 years of monitoring for the nine focal species to generate actual observed distributions in Clark County, and we used the six-year study to generate projected distributions based on habitat. These spatial models can be used for evaluating the possibility of a focal species being present in particular project areas, but with the general precaution that appropriate habitats need to be verified locally to support the species. We further used field vegetation data to generate statistical models of habitat preference for each of the nine species, where sufficient sample sizes were available. These clarified how narrowly, or flexibly, different focal species were associated with habitat types and sources of habitat disturbance present in Clark County.

Finally, we provide a list of all 229 species observed over all point count surveys conducted in Clark County in the past 10 years, and recommendations of how the findings of this study may be used for the planning of future monitoring and conservation action.

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Introduction

The Clark County Multiple Species Habitat Conservation Plan (MSHCP) identified, among other wildlife species, nine landbirds for which the county needed additional inventory and monitoring information in order to better evaluate their countywide status and conservation needs (Clark County 2000). The nine focal species include six species covered by the MSHCP permit and three species under evaluation for future coverage under the permit due to possible conservation concerns. This objective also falls within the mission of the Great Basin Bird Observatory (GBBO), which is a non-profit organization dedicated to providing scientific information toward bird species and habitat conservation in our region. Since 2003, GBBO has been conducting annual inventories and monitoring in Clark County using an all-landbird monitoring protocol that standardizes landbird population monitoring throughout Nevada under the Nevada Bird Count (NBC) program. The purpose of this six-year study (2008 – 2013) that was funded under the MSHCP was to estimate population sizes, develop a monitoring plan, and develop habitat models for the nine focal species. This study was integrated in the NBC program, which allows for regional comparisons and for long-term monitoring using standardized sampling protocols.

The six MSHCP-covered species that are subject to this monitoring project include the Southwestern Willow Flycatcher (*Empidonax traillii extimus*), Blue Grosbeak (*Passerina caerulea*), Phainopepla (*Phainopepla nitens*), Summer Tanager (*Prianga rubra*), Vermilion Flycatcher (*Pyrocephalus rubinus*), and Arizona's Bell's Vireo (*Vireo bellii arizonae*), and the three MSHCP-evaluation species include the Bendire's Thrasher (*Toxostoma bendirei*), Le Conte's Thrasher (*Toxostoma lecontei*), and Gray Vireo (*Vireo vicinior*). Using a habitat stratification approach for random sampling, these focal species were monitored, along with other landbirds, in 12 distinct habitat types of Clark County using point count surveys and intensive area searches as a double sampling approach, as well as other approaches, for determining species detectabilities. Furthermore, we evaluated habitat use and suitability using spatial data and field vegetation assessments to better illuminate habitat requirements of the focal species.

In this final report, we describe the results of six years of inventory and monitoring of nine focal species of the MSHCP program, as well as other landbirds that were monitored under this multi-species sampling plan. Specifically, we present population estimates, habitat suitability models, and spatial habitat models that describe the landscape and resource use of the nine focal species. We further shed light on how these results fit into a regional and larger temporal picture that reaches beyond the scope of this study.

Background

This project was submitted for funding under the MSHCP in 2005, and several meetings were held with Clark County MSHCP science advisors in preparation of the project proposal. In these meetings, the needs for a Clark County landbird inventory and monitoring program were described as having the overarching objectives of (1) determining where on the landscape and in which habitat types the nine focal species are known to occur, and (2) determining whether or not there is a net impact, positive or negative, of Clark County development and mitigation efforts on these species. Additionally, because of the uncertainty in the status of all landbird species, (3) there was an expressed desire to determine the status of other sensitive species in Clark County so that inadvertent omissions from the covered species list would be detected early.

Because of the relatively vague knowledge about most landbirds in Clark County at that time, a random-site-selection, habitat-stratified surveillance monitoring program was proposed and favored by the science advisors. At the time, concerns were expressed that, while the county might be able to demonstrate net benefits of a particular conservation project on the local numbers of a focal species, that the population-level effects would not be known without a surveillance monitoring project that can show county-wide stability, net increases, or net declines in the populations of the focal species. It was argued at the time, and rightfully so, that mitigation for population losses to development in key habitats could not be evaluated quantitatively without a monitoring program that has at least a countywide scope. Ideally, this program would be integrated with current and future effectiveness monitoring projects, which would occur at a local scale and be conducted using compatible monitoring methods. The Nevada Bird Count was designed specifically toward accommodating this approach, which allows the user to view local project effects against a regional background of appropriate bird population data.

Methods

Bird Surveys

Nevada Bird Count (Background)

The Nevada Bird Count (NBC) was initiated in 2002 in order to provide spatially explicit estimates of bird densities and populations in 13 habitat types across the state of Nevada, and to provide a framework for both project-related and statewide monitoring of landbird populations. As a result, the NBC database currently consists of point count data that were collected for a variety of reasons, with the majority of data being from transects that were randomly selected across the 13 habitat strata (based on the original GAP vegetation map), and all other transects being from project-related inventory and monitoring efforts or from historically established transects whose site selection criteria were unknown to GBBO (e.g., most transects established by partner agencies of GBBO). Data collection methods are the same for all transects in the data base, enabling us to use data from statewide randomly-selected transect as baseline or control data for project-related monitoring. Conversely, project-related monitoring is used to inform the statewide program of (non-randomly generated) locations of rare species or the effects of rare habitats or rare habitat conditions. Habitat types that are extensive across the Nevada landscape, such as Mojave scrub, pinyon-juniper, or salt desert scrub were covered by randomly-selected transects, while restricted habitat types had to be covered with mostly non-randomly selected transect locations. The difficulty of rare habitat types, such as lowland riparian, mesquite-catclaw, and wetlands is that they are often in sites to which access is restricted, such as private lands. These habitat types are also often the most species-rich in the desert landscape, which requires adequate sampling of these habitat types for effective population monitoring. Rather than insisting on the fully-randomized design of the program in all cases, we therefore also included non-random sites in rare habitats, particularly in Clark County's riparian areas, mesquite-catclaw, and Joshua tree woodlands. Point count transects that were not randomly selected under the original sampling plan were established with a random start point within a project area or the parcel to which access was available. Finally, while surveys in agricultural areas are usually conducted on roads (as these are part of the agricultural landscape), most point count transects are located randomly with respect to roads, with the first survey point usually located within 2 km of the nearest road access point.

Point Count Transects

The primary method of data collection was a network of variable-distance point count transects, stratified by habitat, which allowed us to extend coverage over a large area and wide array of habitats. Point count transects typically contained 10 survey points and were, on average, 3 km in length. All survey points were georeferenced with a handheld GPS unit. Each point was surveyed for 10 minutes, recording all birds detected by sight or sound. The detections were recorded in three distance intervals (0-50 m, 50-100 m, and >100 m) that were measured with an electronic rangefinder from the survey point. All bird surveys occurred between mid-April and July 7, within the breeding season of most small landbirds in this region. Point count surveys were conducted according to GBBO's standard protocol (www.gbbo.org: Projects). Between 2007 and 2011, 129 transects were surveyed. In 2012 and 2013, 184 transects were surveyed. Sample sizes for all survey years and habitat types are listed in Tables 1 – 2. The locations of all transects are illustrated in Figure 1.

Table 1. Total number of transects surveyed per year in Clark County, by habitat, 2008-2013.

Habitat	2008	2009	2010	2011	2012	2013	Total (2003-2013)
Agricultural	4	4	4	3	1	1	6
Aspen	1	1	1	1			1
Coniferous Forest	4	4	4	6	4	1	12
Joshua Tree	20	19	19	20	17	24	64
Lowland Riparian	20	18	17	14	11	13	47
Mesquite-Catclaw	9	10	9	9	14	20	44
Mojave Scrub	12	13	10	17	16	23	62
Montane Riparian	4[a]	4[a]	4[a]	5[a]	1		6
Montane Sagebrush	1	1	1	1			1
Montane Shrublands	5	3	3	3		3	9
Pinyon-Juniper	9	9	8	9	13	19	44
Salt Desert	8	7	7	9	9	2	21
Total	**97**	**93**	**87**	**97**	**86**	**106**	**317**

[a] Primarily Pinyon-Juniper

Table 2. Total number of survey visits per year in Clark County, by habitat, 2008-2013.

Habitat	2008	2009	2010	2011	2012	2013	Total (2003-2013)
Agricultural	5	4	4	3	1	1	31
Aspen	1	1	1	1			10
Coniferous Forest	6	5	4	6	4	1	47
Joshua Tree	23	32	21	20	17	24	220
Lowland Riparian	24	28	22	20	17	13	198
Mesquite-Catclaw	11	12	10	9	14	20	113
Mojave Scrub	14	13	10	17	16	23	146
Montane Riparian	5[a]	5[a]	4[a]	5[a]	1		48
Montane Sagebrush	2	1	1	1			8
Montane Shrublands	5	4	3	3		3	43
Pinyon-Juniper	12	13	8	9	13	19	114
Salt Desert	8	7	7	9	9	2	67
Total	**116**	**125**	**95**	**103**	**92**	**106**	**1045**

[a] Primarily Pinyon-Juniper

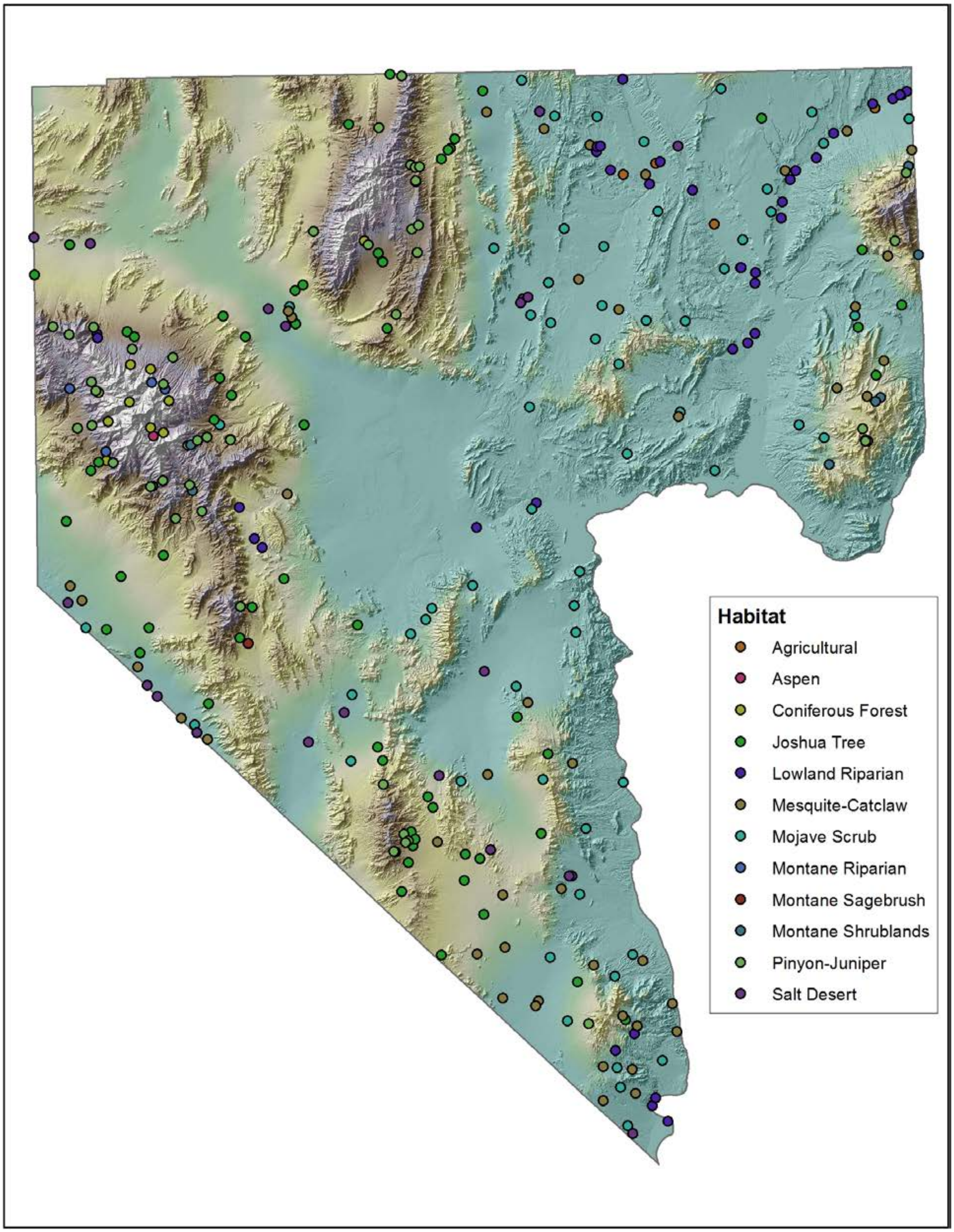

Figure 1. Locations of all transects surveyed within Clark County, by habitat.

Results of the point count surveys are summarized using a standardized density index (number of detections per 40 hectares) that was calculated based on individuals recorded within 100 m of the survey points (a sampling area of 3.14 ha), and excluding fly-over and incidental sightings of birds, as these most likely represent individuals that are not tied by a breeding territory to the sampling location. Transect data from 2003-2011 were from transects established in 2002 on random points created within GAP habitat layers used for stratification; only data from 2008 and later were analyzed in more detail here. The resulting habitat-specific density estimates are provided in two ways, the first was based on the actual observed vegetation type at each transect and therefore more useful for habitat management planning, and the second was based on strata with known sizes which is more appropriate for population size estimation. The latter estimates were bootstrapped to provide 95% confidence intervals, using the percentile method within SYSTAT.

Restratification of Point Count Transects in 2012-2013

Calculating population size estimates for a species requires that the exact size of each sampled stratum (= spatially defined area) is known and that the data represent a random sample from within the stratum. For population size estimation, the habitat stratification is therefore only important in that it ensures that the areas in which a species occurs receive sufficient monitoring coverage rather than being "overlooked" by a random selection that does not consider non-random distribution of birds across the landscape. Actual estimated densities for each stratum are only of interest to the objective of generating countywide population size estimates, not for characterizing habitat preferences or distributional hotspots of a species, which are better addressed by empirical data collection.

Because several improved vegetation layers became available in Clark County during the course of the project, we re-stratified the Clark County sampling area in 2012 to optimize randomization and coverage of sensitive areas. The new stratification also assisted in better characterizing habitat-related density effects on population size estimates and aligning this study with other MSHCP planning efforts based on the same vegetation maps (Heaton et al. 2011). The new stratification resulted in 10 strata based on vegetation cover type. For countywide population estimates, we also restricted the data to only the transect points that were the result of the original random scatter and omitted data from non-randomly placed transects that were added later to meet local project priorities of program partners. The location of the random transects generated after restratification are illustrated in Figure 2. Population estimates were then generated for each stratum by using the average transect-wide density estimate of birds per 40 ha and extrapolating this density into the total area covered by the stratum. Total county-wide population estimates were the sum of the estimated populations of all strata. The metric for estimated densities (birds/40 ha) was selected because (a) bird densities are most often reported this way in the scientific literature, and (b) it is almost exactly the same as birds/100 ac and thus the most user-friendly metric for a land manager.

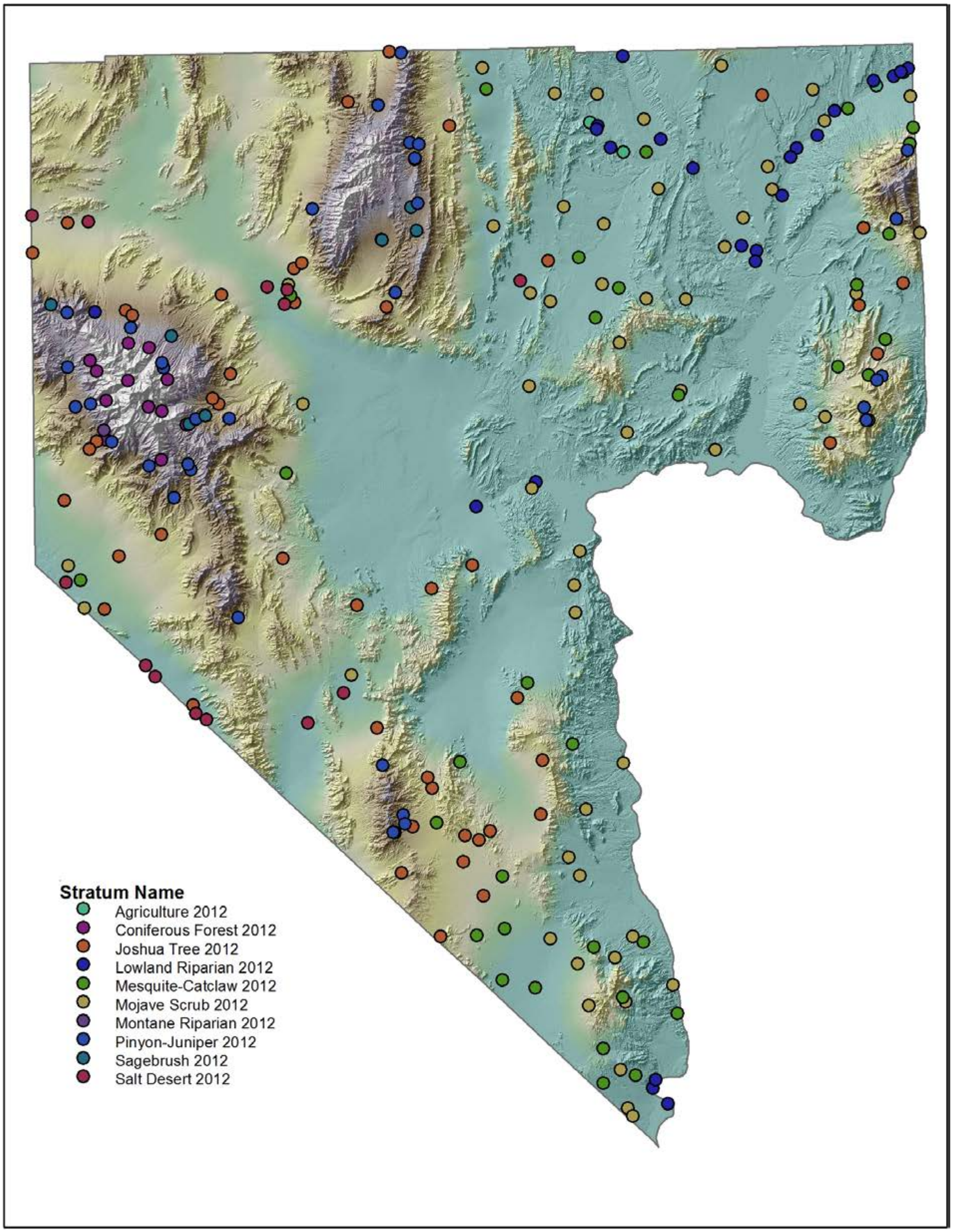

Figure 2. Location of random transects within the 2012 restratification schema.

During the restratification, we also stratified Clark County based on accessibility into the following three strata: (1) an "accessible" stratum that included all publicly accessible lands within 5 km of a usable road; (2) a "remote but accessible" stratum that included publicly accessible areas beyond 5 km of usable roads; and (3) an "inaccessible" stratum that included all other lands (e.g., private and all U.S. Department of Defense/Department of Energy lands).

As a result of the improved vegetation layer used in the restratification, actual and expected habitat types were more congruent, which eases the interpretation of bird survey results. Because the new strata are delineated in blocks rather than irregular polygons and because accessibility is addressed prior to random point selection, the new transect locations are also entirely within one stratum, which was a difficulty in our original stratification. These two improvements allow for more reliable inference of observed data to their appropriate statistical population.

Our data from 2012 and 2013 were collected on new transects randomly selected within the new strata. These data are best considered as one entity, since only one set of random locations was selected to be surveyed over both years. Therefore, while annual estimates are reported separately for 2012 and 2013, better population estimates include data from both years. Population estimates for the years prior to 2012 are also generated using the new Heaton et al. (2011) vegetation map. Sample sizes for all survey years and habitat types based on the new stratification are listed in Tables 3 – 4.

Table 3. Number of strictly random transects surveyed per year in Clark County, by 2012 strata, 2008-2013.

Stratum (2012)	2008	2009	2010	2011	2012	2013	Total (2003-2013)
Agriculture	2	2	2	1	1	2	5
Coniferous Forest	4	4	4	6	5	1	13
Joshua Tree	8	9	8	13	14	25	51
Lowland Riparian	8	8	9	6	9	13	32
Mesquite-Catclaw	1	1	1	1	14	20	33
Mojave Scrub	7	5	4	13	18	21	54
Montane Riparian	0	0	0	0	1	0	1
Pinyon-Juniper	7	6	6	10	10	16	37
Sagebrush	2	2	2	0	3	2	7
Salt Desert	1	1	1	1	9	2	13
Total	**40**	**38**	**37**	**51**	**84**	**102**	**246**

Table 4. Number of survey visits of strictly random transects per year in Clark County, 2008-2013, using 2012 strata.

Stratum (2012)	2008	2009	2010	2011	2012	2013	Total (2003-2013)
Agriculture	3	2	2	1	1	2	16
Coniferous Forest	6	5	4	6	5	1	48
Joshua Tree	11	12	8	13	14	25	121
Lowland Riparian	9	14	12	8	11	13	95
Mesquite-Catclaw	1	2	1	1	14	20	42
Mojave Scrub	8	5	4	13	18	21	95
Montane Riparian					1		1
Pinyon-Juniper	8	10	6	10	10	16	89
Sagebrush	3	2	2		3	2	24
Salt Desert	1	1	2	1	9	2	19
Total	**53**	**53**	**42**	**52**	**87**	**103**	**390**

Determination of Detection Rates

The number of detections of a species is a function of its true density and its probability of detection (Buckland et al. 1993). In order to estimate population sizes for our nine target species, we need to estimate detection rates. The probability of detection depends on several factors including cue production, observer variability, and habitat (Buckland et al. 1993), as well as seasonal effects, breeding status, and nest success (GBBO unpubl. data). Here, we estimate probability of detection using two methods, double sampling and the removal method.

Double Sampling Using Area Search/Spot Mapping

The most straight-forward way to determine overall detection rates is to conduct intensive area-search surveys on a subset of the point count transects, obtaining a complete census of the breeding birds to compare with the more rapid point count method using double sampling (Bart and Earnst 2002, Collins 2007). By comparing point count results to the known territories and number of birds present from the intensive area searches, we are able to determine average detection rates. The density measures from the intensive area search/spot mapping effort are unbiased if (1) the intensive survey sites are randomly selected, if (2) the point count transects are conducted in the same manner regardless of whether they are located on the area search plot or elsewhere in the stratum, and if (3) the number of birds on the area search plot can be measured without error (Bart and Earnst 2002).

The intensive survey plots were randomly selected from the pool of point count transects in the primary habitat types used by the nine target species. In areas with high breeding bird densities (e.g., riparian areas), the plots were relatively small (less than 9 ha), but in lower-density habitats (e.g., Joshua tree or salt desert) the plots were larger (typically 16 or more ha). The plots were completely surveyed on each visit between sunrise and 11 a.m. in fair weather conditions and during the same sampling period as used for point count surveys. Each plot was visited 8 - 10 times in a season, with each visit separated by 4 - 7 days, which is enough to determine breeding bird activity on the plot and the presence/number of non-breeding individuals throughout the breeding season based on previous efforts (GBBO unpubl. data). Area searches also result in breeding phenology data for our target species that can inform land management planning directly and assist in breeding season bias corrections to the point count data.

Once the plot was laid out in the field and on a map, the surveyors recorded all bird activity using a grid search through the plot. The location of each bird or bird group is recorded on the map and the layout of each territory is determined at the end of each visit. Nesting evidence was explicitly recorded, as it not only determines the location of breeding territories, but also the stage of breeding activity. Special attention was placed on partial territories near the plot boundary; surveyors delineated the territory on both sides of the area search plot boundary to determine the proportion of territory within the area search plot. For each sighting location, the number of individuals was recorded during each visit and mated pairs or family groups are identified as such. Finally, observers used the maps from all visits to determine the best estimate of the territory locations and sizes for all target species within the plot. The number of territories for each species was determined from this composite map, and densities could then be calculated by dividing by the area of the plot.

Our rapid survey method used for determining detection probabilities consisted of a series of point counts within the intensive area search plot, which were completed using the same methods as for the county-wide random point count coverage. Area search locations were then overlapped with point counts, such that at least 5-6 100-m-radius points were fitted within the plot boundaries (overlapping survey areas were acceptable for point counts in this case, as detection rates are determined using each double-sample point count as an estimate of detection probability). A surveyor other than the person who conducted the area searches (i.e., naïve observer) conducted the point counts. To calculate density estimates from this rapid method for comparison to the intensive surveys, birds were tallied within 100 m of the point only as the effective area of the survey. Data from the multiple points on a given plot were then averaged for each visit to obtain an overall density estimate.

We conducted intensive area searches on 35 plots around Clark County, in six habitat types of the original stratification: Joshua tree (3 plots), lowland riparian (13 plots), mesquite-catclaw (4 plots), Mojave scrub (4 plots), pinyon-juniper (6 plots), and salt desert (5 plots). These surveys accumulated relatively slowly over the years because they are labor-intensive.

Some focal species were too rare to calculate detection rates using data from each species alone. We therefore grouped the species with others that likely have a similar detection probability based on singing rate, song volume, activity level, color, and perch positions (Alldredge et al. 2007b), presented in Table 5. Densities of each group were then calculated from both rapid and intensive survey plots as if they were a single species. Densities and detection ratios were calculated separately for the six habitat types.

Table 5. Groups of species with similar detectability that were analyzed together for double sampling. All scientific names of species are listed in Appendix 1.

Species	Number of plots with presences	Detectability group
Bendire's Thrasher	1	**1**
Crissal Thrasher	10	
Le Conte's Thrasher	4	
Black-throated Gray Warbler	4	**2**
Gray Vireo	3	
Plumbeous Vireo	2	
Virginia's Warbler	2	
Bell's Vireo	4	**3**
Bewick's Wren	13	
Dusky Flycatcher	4	**4**
Gray Flycatcher	4	
Lazuli Bunting	1	
Western Wood-Pewee	3	
Willow Flycatcher	4	
Black-headed Grosbeak	5	**5**
Blue Grosbeak	7	
Bullock's Oriole	10	
Summer Tanager	5	
Vermilion Flycatcher	7	
Yellow-breasted Chat	8	
Ash-throated Flycatcher	19	**6**
Brown-crested Flycatcher	6	
Phainopepla	11	

Removal Method

Removal models can be applied to the NBC point count data, since the data are collected using multiple time periods (e.g., Farnsworth et al. 2002). The assumptions of the removal method are those of population closure, no double-counting, that all easily-detected individuals are in fact detected, that less easily detected individuals have a constant detection rate, and that observers accurately assign distances. While some violation of these assumptions may occur, GBBO's intensive surveyor training program minimizes count and distance inaccuracies. In spite of potential violations in detection rate assumptions (Alldredge et al. 2007a), the method is considered fairly robust (Farnsworth et al 2002). Because of the method's assumption that populations are closed, these removal models are best suited for species with relatively small territory sizes (Farnsworth et al. 2002, Moore et al. 2004), which makes it a suitable method for the nine focal species, though some more so than others. This method is also best suited for species with intermediate or high probabilities of detection (Moore et al. 2004), which is a reasonable assumption for the nine focal species due to their repeated vocalizations and active behavior. In the more recent survey years, GBBO crews have also collected data in 1-minute increments, and this subset of the data was analyzed using the program MARK.

The use of both the removal and the double-sampling methods allowed us to take advantage of each method's strengths for estimating bird detectability, and it allowed us evaluate their use in long-term monitoring of the nine focal species. The removal analysis is the most resource-efficient method, and it can use all detections from point count surveys (while the double sampling method only uses data from area search plots). Its disadvantages are that it is vulnerable to population closure violations and performs poorly when detection probabilities are low. The advantage of the intensive area searches for double-sampling is that the amount of time spent on site ensures that the true density is assessed and that additional, biologically important data can be collected on breeding phenology. Its disadvantages are that the surveys are extremely resource-intensive and that focal species actually need to be present in the randomly-selected intensive survey sites in order to calculate detection ratios.

The removal analysis reported here limits bird detections to those recorded within 100 m, and groups these into five 2-minute intervals. With no double-counting during the survey, an individual that, for instance, was detected in minute 3 would therefore be given a zero-one encounter history of 01000 (i.e., a 0 for the 1-2 min interval, a 1 for 3-4 min, and 0s for all other intervals). Only detections of adult birds were included in this analysis, and sexes were not distinguished. The analyses were based on closed capture-recapture models. When a clear top models could be selected, models with AICc values within 2 units of the top model were model-averaged within MARK. Top models were also selected to run heterogeneity models, which performed poorly when small samples were included, even when probabilities were pooled between groups. Therefore, heterogeneity models were performed only for groups with at least 10 detections. For some species/strata combinations, population sizes could be estimated within the non-heterogeneity capture models, but not the heterogeneity models. Where heterogeneity models could be estimated, their results were reported, and where they could not, only the simple capture-recapture model results were reported.

Detections for Blue Grosbeak, Summer Tanager, and Vermilion Flycatcher were insufficient for individual removal analysis on these species. However, these species were assumed to have similar detection rates and were thus analyzed together. We constrained the detection rates to be the same among these species, but also generated estimates for each species-habitat group within the analysis.

For all species, except Phainopepla, detections from all habitat types were lumped together because of low sample sizes; based on typical vegetation density in the lumped habitats and its potential impacts on detectability, this also seemed biologically reasonable. For Phainopepla, we had sufficient data to test for a habitat effect on detection rate when lumping together detections from Lowland Riparian and Agriculture, as well as lumping detections from Mesquite-Catclaw and other upland habitats in another group. This approach also seemed reasonable based on typical vegetation densities in the lumped habitats and their potential impacts to detectability. The best models did not include a habitat effect, so detections from all habitats were lumped together in the final analyses to estimate overall detection rates. Population estimates, however, were generated for each species-habitat combination within the analysis.

Le Conte's Thrashers detections were lumped with Crissal Thrasher detections in non-Lowland Riparian/Agriculture strata in the MARK analysis (excluding data from riparian and agriculture because of the potential for denser lowland riparian habitats to impact detection probabilities of Crissal Thrashers). While the detections declined as expected over the count period through minute 8, in minutes 9 and 10, there was a large jump in the number of detections in both species, suggesting a violation of the population closure assumption. The fifth encounter period was therefore trimmed from the analysis. The combined detection probability rate was then used to generate population estimates for Le Conte's Thrashers within the appropriate habitats. There were insufficient data for analyzing Bendire's Thrasher and Willow Flycatcher detection rates using the removal method.

Habitat Data Sources

Conceptual Models

Conceptual models present a simplified schematic of intricate ecological processes and complicated cause-and-effect relationships. The conceptual models for the nine focal species are summarized below, and they focus on the major stressors (threats) present in Clark County today, how these are expected to affect the primary habitat of the bird species, and what responses are expected from the bird species with regard to nesting, survival, and population ecology. More details on the conservation issues of conservation priority bird species and the habitat types present in Clark County can be reviewed in GBBO (2010).

Map Products and Use of Spatial Data

The original habitat stratification for this project used aggregated vegetation layers from the first GAP vegetation mapping project (Homer 1998), which was completed for Nevada in 1990 (the more recent Southwest Re-GAP project had not yet been completed). As with all remote vegetation mapping projects, the original GAP project included misclassifications and limitations in mapping resolution that affected sampling stratifications such as the one done for this bird monitoring project. For instance, habitat patches that were smaller than the resolution of the GAP map were automatically misclassified as the more common surrounding habitat type. This affected particularly riparian areas, especially those associated with small desert spring outflows, as well as mesquite or acacia stands that are associated with ephemeral washes in Clark County. Other misclassifications are the result of remote methods not being able to detect a vegetation component that is critical to birds, which was particularly true for *Yucca* woodlands including Joshua trees in Clark County. Finally, some misclassifications were the result of remotely recorded signatures of vegetation not being sufficiently distinguishable from others, or because vegetation covers had changed. For these reasons, our field surveyors often encountered habitat types at random points that were different than the GAP classification of a given transect.

We feel that estimated bird densities for the actual, field-observed habitat types are critical for land managers for the following reasons:

- They provide an average expected density for a given species in that habitat type
- They can therefore be used to rank a conservation site for that species
- They can therefore be used for effectiveness monitoring of a conservation or restoration project that targets that species

In addition to the original habitat map from GAP, we consulted two new vegetation maps for interpretation of our data, (1) a new vegetation classification based on LandFire that includes vegetation condition classes and was developed by The Nature Conservancy for the Nevada Wildlife Action Plan (Provencher and Anderson 2011), and (2) a recently developed vegetation map and vegetation models completed for Clark County by Heaton et al. (2011). The Nature Conservancy's Nevada habitat map (Provencher and Anderson 2011) has the advantages over the original GAP classifications of (1) having a finer mapping resolution based on smaller mapping units, (2) indicating stand condition classes that represent different degrees of habitat degradation, and (3) having LandFire's improved remote sensing methods. These factors contributed to more realistic portraits of bird habitats, but even this mapping effort had disadvantages. For instance, as with other remotely-generated maps, *Yucca* landscapes still could not be delineated without ground-mapping, and many small habitat patches, such as spring outflows, mesquite-acacia washes, and small aspen stands may still be missed despite the finer resolution of the new maps. Also, the irregular and linear habitat patches of riparian areas may be poorly represented, which affects our ability to use the map for habitat suitability estimates of riparian birds. The Clark County map (Heaton et al. 2011) remedied many of these problems by including a significant amount of ground-truthed habitat delineations, which was particularly important for *Yucca* and mesquite-acacia stands.

Field Vegetation Assessments

We conducted vegetation assessments in the field at over 2000 data points along the surveyed bird transects over the course of the project. These vegetation data were used for modeling the relationships of focal bird species to local habitat features that are not measurable through remote sensing. We collected three types of vegetation data in the field sites. First, observers recorded the presence or absence of a series of landscape features such as roads, development, water, dry washes, tall cholla, mesquite-mistletoe, or trees (including Joshua trees and Mojave yuccas) at different distance categories. Abundance classes of tall cholla and mistletoe were also collected when present. The observers also recorded a list of all identifiable dominant plant species within 100 m. Finally, they collected angle-order data, a plotless density estimation method, which we analyzed using the point-centered quarter method (Engeman et al. 1994); this method can also be used to estimate occurrence frequency for focal plants. Distances from the bird survey point to the nearest woody plants within five height classes were recorded using this method, and these could then be transformed into density estimates for each height class together, or for individual plant species. The height classes considered here were 0 to 0.5 m, 0.5 to 1.5 m, 1.5 to 4 m, 4 to 10 m, and greater than 10 m height. Woody plants were assigned to height classes by their maximum height, and they were not double-counted among height classes.

Habitat Suitability

In this report, wepresent habitat suitability data for the nine focal species the following four ways:

Population density table: We calculated a density estimate (detections per 40 ha; uncorrected for detectability) for each species in each of 12 habitat types (Appendix 2). For this, we determined the predominant habitat at each transect in the field rather than relying on the original GIS strata. The population density table summarizes the data from all of the 316 transects we have surveyed in Clark County since 2003.

Habitat distribution: We show histograms of the distribution of the focal species across habitat types as determined by the GIS vegetation map for Clark County by Heaton et al. (2011). Habitat cover based on this map was determined for each survey point, rather than for the entire transect, using the predominant vegetation type within 100 m of the survey point (see the Habitat Use section below for more details).

Field vegetation models: The vegetation data collected in the field at over 2000 points were used to perform a series of ANOVA and logistic regression analyses, exploring the relationships of each focal bird species with local habitat and landscape elements likely to be important to habitat quality (see the Statistical Habitat Models section below for more details).

Distribution maps: We constructed two predictive distribution maps for each species with sufficient sample size, using both of the available spatial data sets that mapped (GIS) vegetation data for Clark County and the surrounding Mojave Desert areas of Nevada (see the Spatial Habitat Models section below for more details).

Habitat Use

For the general distribution of the focal species across broad habitat types, we used the GIS vegetation maps developed for Clark County by Heaton et al. (2011). We combined this Ecosystem map with a new, ground-truthed Joshua tree layer from Clark County, creating combination categories of ecosystems with and without Joshua tree (Table 6). Habitat cover was summarized for each survey point, rather than for the entire transect. If more than one habitat was mapped within 100 m of the survey point (the effective area of the bird surveys), the point was assigned to the habitat with the greater structural complexity present. If Joshua tree (or other Yuccas) was present within 100 m, the survey point was assigned to a Joshua tree combination.

The frequency of detection locations in different habitat classes was then plotted in histograms to illustrate habitat preference and specialization. The data are presented in histograms for all habitat classes with more than 40 survey points. We used all data collected since 2008, including 3,013 point counts on 310 transects.

Table 6. Distribution of point counts across combined habitat categories from GIS vegetation maps developed for Clark County by Heaton et al. (2011), with total areas within county.

Combined Habitat Category	Total Hectares in Clark County		Point Counts
	No Joshua Tree	With Joshua Tree	
Water	27,856		0
Disturbed	112,452		53
Joshua Tree/Disturbed		66	0
Desert Riparian	9,262		321
Joshua Tree/Desert Riparian		0	0
Mesquite/Acacia	14,016		274
Joshua Tree/Mesquite/Acacia		2,830	180
Salt Desert Scrub	45,570		86
Joshua Tree/Salt Desert Scrub		38,600	58
Mojave Desert Scrub	933,578		553
Joshua Tree/Mojave Desert Scrub		332,568	412
Blackbrush	63,940		27
Joshua Tree/Blackbrush		351,671	381
Sagebrush	2,176		33
Joshua Tree/Sagebrush		2,522	48
Pinyon/Juniper	103,273		246
Joshua Tree/Pinyon/Juniper		12,600	190
Mixed Conifer	27,336		131
Bristlecone Pine	7,564		20
Alpine	124		0
TOTAL			**3013**

Statistical Habitat Models

Field vegetation data were available for 2,000 points on 246 transects. Categorical data on the presence or absence of key habitat and landscape elements at different distances lend themselves well to ANOVA analyses predicting the mean abundance of the focal species (except Willow Flycatcher which only had a sample size of 2). The presence or absence of key plant species were also derived using the field-generated plant species lists and analyzed in the same way using ANOVA.

The plotless plant density estimation was used for logistic regression analysis testing the difference between plots occupied and unoccupied by a focal species. The point-centered quarter method (Cottam and Curtis 1956) estimated the density of woody plants in five height classes by converting distances to the first plant in each quarter to plants/ha according to Mitchell (2007). Because density was calculated at the point level, sampling or measurement errors had a potentially large effect, producing outliers with overly inflated densities. We therefore deleted some outliers with extreme densities.

We also recorded the species of each of 23,025 plants, and these data were used to calculate the proportion of the overall density, in different height classes, represented by plant species that were common enough for analyses (Table 7). For overall species proportions, all height classes were lumped together.

Logistic regression was used to determine the effect of plant densities and species proportions on the presence or absence of each focal bird species. The effect of elevation was also included in this analysis since it is a critical environmental variable for most bird species. As did the ANOVA analyses, the logistic regression analyses included data from all habitats combined.

Table 7. Plant species used in the statistical habitat models for the nine focal species, with total number sampled in each height class of the plotless distance sampling (point-centered quarter).

SPECIES	Common Name	0 to 0.5 m	0.5 to 1.5 m	1.5 to 4 m	4 to 10 m	> 10 m	Total
Acacia greggii	Acacia	18	125	662	32	0	837
Artemisia sp.	Sagebrush	449	212	8	0	0	669
Atriplex sp.	Saltbush	315	309	25	0	0	649
Coleogyne ramosissima	Blackbrush	524	385	34	0	0	943
Cylindropuntia	Cholla	64	108	61	1	0	234
Juniperus sp.	Juniper	12	47	408	242	11	720
Larrea tridentata	Creosote	243	2,000	2,180	3	0	4,426
Pinus monophylla	Pinyon pine	71	127	365	715	221	1,499
Pinus longaeva	Bristlecone pine	0	1	3	4	2	10
Populus fremontii	Fremont cottonwood	0	0	6	31	21	58
Prosopis sp.	Mesquite	12	37	205	85	1	340
Purshia stansburiana	Cliffrose	40	89	134	3	0	266
Salix sp.	Willow	8	22	57	45	2	137
Tamarix ramosissima	Saltcedar	112	136	399	159	0	806
Yucca brevifolia	Joshua tree	11	45	880	531	0	1,467
Yucca schidigera	Mojave Yucca	9	162	525	9	0	705
Total		**6,630**	**7,205**	**6,766**	**2,014**	**410**	**23,025**

Observed Actual Distribution

To create the actual-distribution maps, we included all Nevada Bird Count point locations where each focal species was recorded between 2003 and 2013, including incidental observations. In addition, we included species locations from the Nevada Breeding Bird Atlas data collection, 1998-2000 (Floyd et al. 2007), including incidental records denoted by a triangle to visually separate them from the point count records. It should be noted, however, that survey records from the atlas period were mapped with a UTM coordinate from the corner of the atlas block, rather than from the actual location of the bird, which introduces a slight mapping error for these records.

Spatial Habitat Models

Predictive distribution maps based on habitat models can be very useful for county planning because they combine actual species distribution with each species' basic habitat preference. We created two different maps for most species, using the two available spatial data sets that mapped vegetation of Clark County and the surrounding Mojave Desert areas of Nevada. First, we used the most recent Clark County vegetation layer (Heaton et al. 2011) that provided more accurate and detailed delineations of the bird-habitat types than were previously available for the county. Second, for a regional predictive model, we used spatial data from the new statewide vegetation classifications based on LandFire that include condition classes within vegetation types, and were developed by The Nature Conservancy for the Nevada Wildlife Action Plan (Provencher and Anderson 2011).

In both predictive models, we used the frequency of bird detection locations in different habitat classes to predict average expected densities in areas with similar habitat cover types. For this, habitat cover at detection locations was summarized for each survey point, and prevalence of vegetation cover within 100 m of the survey point was used to determine the dominant vegetation for each point at which a species was detected. The resulting habitat-specific densities were then projected across the region to create the maps. Each map set uses the same color scheme for all species for comparison, but different shades and different density metrics were used based on the map source. Densities per count, as reported for one map, can be converted to densities per 40 ha by multiplying it by 12.73.

The Nature Conservancy vegetation map had a slightly finer scale and more habitat categories than did the Clark County map, so predictive maps produced with this LandFire-derived product generally shows more gradations in density throughout the range. The Clark County map has broader expanses for fewer habitat types, and most species were found in only 8 or fewer of those categories.

Results and Discussion

All Species

Overall, 229 bird species were recorded during all our past bird surveys in Clark County. All species observed during this study and previous monitoring efforts, and all scientific names of bird species are listed in Appendix 1, and all density estimates (uncorrected for detectability) for the species observed during this six-year project are listed, by habitat type, in Appendix 2. In Appendix 2, we also identify other conservation priority species besides the focal species of this study, and these priority rankings are based on GBBO (2010). In the following, we give a brief overview of the findings for all other landbirds of conservation interest, by habitat type, before describing the results for our nine focal species.

Agriculture

In agricultural lands, the most abundant species were habitat generalists and those tolerant of human activity, e.g., House Sparrows, Mourning Doves, Gambel's Quail, Western Meadowlarks, House Finches, Red-winged Blackbirds, and Brown-headed Cowbirds. Ten conservation priority species (according to GBBO 2010) were also found in agricultural lands (Appendix 2), which includes Gambel's Quail in the top ten most abundant species of this habitat type. While Gambel's Quail was found in all Clark County habitat types except for aspen and coniferous forest, agricultural lands were one of the most important for the species. Lucy's Warblers and Abert's Towhees were also generalist species with eight and five habitats used, respectively, but agricultural lands were one of the most important habitats for these species, as well. Four focal species were also recorded in agricultural lands, including Phainopepla, Vermilion Flycatcher, Bell's Vireo, and Blue Grosbeak.

Aspen

We only surveyed one transect that was completely in aspen habitat due to the rarity and poor accessibility of this cover type. However, six species of conservation concern were recorded in our aspen transect, of which the Green-tailed Towhee was the most abundant (9th overall). While the Green-tailed Towhee was a generalist based on our data (recorded in nine habitats), they were found in greatest numbers in aspen. The most abundant species is aspen were Warbling Vireo, Hermit Thrush, Broad-tailed Hummingbird, Chipping Sparrows, Yellow-rumped Warblers, Dark-eyed Juncos, Dusky Flycatchers, and Cassin's Finches. No focal species were recorded in aspen.

Coniferous Forest

Coniferous forest transects often included significant amounts of pinyon-juniper habitat, as well. The most abundant species in this habitat included Chipping Sparrow, Mountain Chickadee, Dark-eyed Junco, Cassin's Finch, Yellow-rumped Warbler, Broad-tailed Hummingbird, Western Tanager, and Ruby-crowned Kinglet. Thirteen conservation priority species were recorded in coniferous forest, of which the Green-tailed Towhee was most abundant. None of the ten most abundant species in this habitat were conservation priorities, but the focal species Gray Vireo was detected in this habitat type.

Joshua Tree

Joshua tree habitats were characterized by a significant Joshua tree and/or Mojave yucca component. The most abundant species in this habitat type were Black-throated Sparrows, Ash-throated Flycatchers, Cactus Wrens, Scott's Orioles, Pinyon Jays, and House Finches. Seventeen conservation priority species were recorded in this important habitat type. In fact, three of the ten most abundant species were conservation priorities, including Pinyon Jay, Brewer's Sparrow, and Gambel's Quail. Pinyon Jays were recorded in six habitats. Unsurprisingly, pinyon-juniper was the most important of these for the thus-named Pinyon Jay; however , Joshua tree habitats were not far behind. Brewer's Sparrows (made up primarily of migrant individuals in Clark

County) were found in nine habitats, of which Joshua tree was one of the two most important. Joshua tree habitats also supported five focal species, including Bell’s Vireo, Gray Vireo, Bendire’s Thrasher, Le Conte’s Thrasher, and Phainopepla.

Lowland Riparian

Lowland riparian habitats were by far the most species-rich of the habitat types we surveyed, with a total of 167 species. The most abundant of these species included Gambel’s Quail, Mourning Doves, Lucy’s Warblers, Red-winged Blackbirds, Abert’s Towhees, Yellow Warblers, and Brown-headed Cowbirds. In addition, 35 conservation priority species were recorded in lowland riparian habitats. Three of these were among the ten most abundant species of this habitat type, including Gambel’s Quail, Lucy’s Warbler, and Abert’s Towhee. While Gambel’s Quail was recorded in all of the habitats surveyed except for aspen and coniferous forest, lowland riparian was the most important for the species. Similarly, Lucy’s Warblers and Abert’s Towhees were generalist species based on these data (recorded in eight and six habitats, respectively), but both were most abundant in lowland riparian. All nine focal species of this study were also recorded within or near lowland riparian habitat.

Mesquite-Catclaw

The most abundant species of mesquite-catclaw habitats included Black-throated Sparrows, Gambel’s Quail, Verdin, Ash-throated Flycatchers, and Black-tailed Gnatcatchers. Sixteen conservation priority species were also recorded in mesquite-catclaw and, in fact, two of these were among the ten most abundant species in this habitat type, including Gambel’s Quail and Brewer’s Sparrow. While Gambel’s Quail was recorded in all of the habitats surveyed except for aspen and coniferous forest, mesquite-catclaw was one of the most important for the species. Lucy’s Warblers were also generalist species based on these data (recorded in eight habitats), but mesquite-catclaw was one of the most important habitats. Brewer’s Sparrows were recorded, primarily as migrating individuals, in nine habitats, and mesquite-catclaw was one of the more important habitats. Unidentified “Sage” Sparrows (this species was split into Sagebrush and Bell’s sparrows in 2013) included migrating Sagebrush Sparrows and breeding or migrating Bell’s Sparrows. These were found in six habitats, with mesquite-catclaw and montane riparian slightly more important than other habitats. Five of the focal species were recorded in mesquite-catclaw, including Bell’s Vireos, Gray Vireos, Bendire’s Thrashers, Le Conte’s Thrashers, and Phainopepla.

Mojave Scrub

By far the most abundant species within Mojave scrub habitats was the Black-throated Sparrow, distantly followed by Rock Wrens, Horned Larks, Ash-throated Flycatchers, Gambel’s Quail, and Cactus Wrens. Fourteen conservation priority species were also recorded in Mojave scrub, including two that were among the ten most abundant species, Gambel’s Quail and Brewer’s Sparrow. In addition, four focal species were recorded, Gray Vireo, Bendire’s Thrasher, Le Conte’s Thrasher, and Phainopepla.

Montane Riparian

Most of our montane riparian transects were surrounded, and often dominated, by pinyon-juniper. The most abundant species were Spotted Towhees, Chipping Sparrows, Western Scrub-Jays, Black-throated Gray Warblers, Blue-gray Gnatcatchers, Bushtits, and Broad-tailed Hummingbirds. None of the 15 conservation priority species recorded in montane riparian habitats were among the ten most abundant species of this habitat type. Black-chinned Sparrows were somewhat of a generalist species according to these data, recorded in nine habitats, but montane riparian was one of the two most important habitats. Unidentified “Sage” Sparrows were found in six habitats, with mesquite-catclaw and montane riparian slightly more important than the other habitats. Three focal species were also recorded on these transects, including Bell’s Vireo, Gray Vireo, and Phainopepla.

Montane Sagebrush

Montane sagebrush transects supported four conservation priority species, one of which was among the ten most abundant, Gambel’s Quail. The most abundant species was Black-throated Sparrow, followed by Ash-throated Flycatcher and Cactus Wren. No Clark County focal species were recorded in montane sagebrush.

Montane Shrubland

The most abundant species in montane shrubland transects were Spotted Towhee, Black-throated Sparrow, Black-throated Gray Warbler, Bushtit, Western Scrub-Jay, Blue-gray Gnatcatcher, and Ash-throated Flycatcher. Thirteen conservation priority species were also recorded in montane shrublands, none of which were among the ten most abundant species. Three focal species were recorded, including the Gray Vireo, Le Conte’s Thrasher, and Summer Tanager.

Pinyon-Juniper

Pinyon-juniper transects supported the second-highest species richness (106 species) after lowland riparian. The most abundant species were Spotted Towhee, Blue-gray Gnatcatcher, Black-throated Gray Warbler, Black-throated Sparrow, Western Scrub-Jay, Ash-throated Flycatcher, and Gray Vireo. Eighteen conservation priority species were recorded in pinyon-juniper woodlands, and two of these were among the ten most abundant, Gray Vireo and Pinyon Jay. Pinyon Jays were recorded in six habitats, with pinyon-juniper being the most important. Pinyon-juniper was also one of the two most important habitats for the Black-chinned Sparrow. In addition, pinyon-juniper supported four focal species, the Bell’s Vireo, Gray Vireo, Phainopepla, and Blue Grosbeak.

Salt Desert

Salt desert supported the fewest number of species of any habitat that we sampled. The most abundant species in salt desert sites were, by far, Horned Larks and Black-throated Sparrows, followed by Ash-throated Flycatchers, Cactus Wrens, and Gambel’s Quail. Nine conservation priority species were also recorded, including Gambel's Quail that was among the ten most abundant species in this habitat type. Salt desert sites also supported three of the Clark County focal species, the Gray Vireo, Le Conte's Thrasher, and Phainopepla.

Bell's Vireo (Covered Species)

Photo and Rights: Martin Meyers

Conceptual Model

Bell's Vireos are moderately common in Nevada's Mojave riparian habitats, and they are a conservation concern due to their recent significant population declines (GBBO 2010). The species nests – and forages – in the mid-canopy of relatively intact native riparian woodland and, unlike the Summer Tanager, does not strictly require mature, tall riparian trees. It is often found in mid-successional stages of riparian woodlands, and also makes extensive use of riparian mesquite. Bell's Vireos also occur in low densities in some stands of upland and dry-wash mesquite, but we documented a significant, negative correlation of the species with distance to surface water (GBBO 2010). The biggest ecological stressors identified in the conceptual model for species conservation are all factors that cause decreased plant vigor and mortality in the species' preferred woodland habitats (Figure 3). As a species of riparian environments, urban and agricultural uses, reduced water availability, and effects of climate change may all impact Bell's Vireo populations. Because the species is migratory, its responses to environmental impacts in Clark County are most likely seen during the breeding season and short periods before and after nesting. These responses may include decreased foraging success, increased adult stress responses, decreased reproductive success, and ultimately, fragmentation of the currently cohesive breeding population which will lead to increased population fluctuations and fluctuations in breeding success.

Ecological Stressors → **Important Habitat Effects** → **Expected Bell's Vireo Responses**

Ecological Stressors

Structural Change

- Habitat conversion: urbanization, energy development, transportation corridors, catastrophic fires
- River channelization, impoundment, floodplain conversion to agriculture
- Recreational facilities

Change in Processes

- Introduced weeds
- Climate change
- Drought
- Change in fire regime
- Ungulate grazing
- Change in river flow regimes and groundwater tables

Important Habitat Effects

Habitat Loss

- Fragmentation and loss of riparian woodlands
- Loss of riparian shrub cover
- Loss of floodplain wetlands

Habitat Degradation

- Water stress/mortality in canopy trees
- Reduced riparian tree recruitment
- Decreased tree age class diversity
- Loss of native shrub and wetland covers
- Decreased water availability in soils and floodplain wetlands
- Decreased wetland invertebrate populations

Expected Bell's Vireo Responses

Nesting

- Loss of suitable nest sites
- Increased territory sizes
- Increased nest failure rate
- Decreased reproductive output

Survival

- Longer travel for foraging
- Reduced foraging success
- Increased unpredictability of prey
- Stress response to loss of water and thermal shelters

Population

- Reduced recruitment of young
- Reduced site fidelity
- Decreased population size
- Fragmented population
- Increased population fluctuations

Recommendations for the Development of Indicators of Bell's Vireo Population Effects:
Baseline data on territory sizes, locations, nests (and nest success, if possible) in randomly selected occupied sites in Clark County. Research on prey use and availability to develop a simple indicator prey species monitoring plan. Long-term population monitoring of Bell's Vireos.

Figure 3. Bell's Vireo conceptual habitat model, Clark County.

Density and Population Estimates

Bell's Vireos were recorded primarily in lowland riparian, and secondarily in agricultural, habitats within Clark County (Table 7). Densities in lowland riparian habitats were higher (1.63 detections/40 ha) than in agricultural habitats (0.96 birds/40 ha); however, their confidence intervals overlapped. Density estimates using double-sampling were quite similar to those using the raw data. However, the removal modeling suggested higher densities in lowland riparian habitats (3.90 birds/40ha), such that the confidence intervals between the double-sampling estimates and the removal estimates only barely overlapped.

Our uncorrected density estimates for Bell's Vireo are quite a bit lower than those found by Szaro and Jakle (1985) in central Arizona, where they recorded densities greater than 20 birds/40 ha in riparian edge habitats, and approximately 9 and 12 birds/40 ha in desert washes, though these trends parallel our findings with regard to distance to water (GBBO 2010). Brand et al. (2010) also found higher densities along the San Pedro River (Arizona) within riparian and mesquite habitats, where they recorded approximately 11.7 to 14.9 birds/40 ha. Our results from Clark County are similar to those recorded by Krueper et al. (2003) before and shortly after cattle were removed from the San Pedro River, where they reported approximately 1.5 to 4.3 birds/40 ha. In other regions of the Southwest, Bell's Vireo has also been reported to use urban areas that contain at least some native vegetation (averaging 1.4 birds/40 ha), but were found in greater numbers in desert areas with native vegetation (averaging 5.8 birds/40 ha, Mills et al. 1989).

The population estimate for the agriculture stratum of Clark County is similar using both correction methods for detectability (Table 7). The overall population estimates from the two methods were, however, influenced by the difference in density estimates between the removal and double-sampling methods from the lowland riparian transects. Using the double-sampling, we have an estimated 363 Bell's Vireos throughout the county, while using removal modeling, we have an estimated 758 individuals in the county. Some of these differences may be due to the relatively low number of area search plots that contained Bell's Vireos, from which the detection ratio was derived. The confidence interval for the removal estimate is also fairly wide, however.

Annual population estimates from double-sampling varied over the six years of the study, ranging from a low of 78 to a high of 843; the two years with the lowest estimates for lowland riparian habitatswere 2012 and 2013. These results may in part be due to the different distribution of transects from the restratification, but many of the transects with the greatest numbers of Bell's Vireos along the Virgin River had also recently been impacted by a large flood event in December 2010.

Table 7. Estimated density and population size of Bell's Vireo in Clark County by year and habitat stratum, 2008-2013.

Stratum	2008	2009	2010	2011	2012	2013	2012-2013	Overall (2003-2013)
Agriculture								
Raw density of detections	0.32 (0, 0.64)					1.82 (N/A)	1.21 (0.61, 1.82)	0.96 (0.36, 1.56)
Density Estimates (Double-Sampling)	0.32 (0, 0.64)					1.86 (N/A)	1.24 (0.62, 1.86)	0.98 (0.36, 1.59)
Density Estimates (Removal)	N/A					N/A	N/A	0.86 (0.31, 11.53)
Raw population size estimate	21.5 (0, 43.1)					123.1 (N/A)	82.0 (41.0, 123.1)	64.7 (24.2, 105.3)
Population Size (Double-sampling)	22.0 (0, 44.0)					125.5 (N/A)	83.7 (41.8, 125.5)	66.0 (24.6, 107.5)
Population Size (Removal Modeling)	N/A					N/A	N/A	58.7 (20.8, 780.0)
Lowland Riparian								
Raw density of detections	1.31 (0.32, 2.75)	3.58 (2.12, 5.10)	4.61 (2.76, 6.42)	3.58 (2.12, 5.10)	0.42 (0, 0.99)	0.82 (0.20, 1.60)	0.69 (0.24, 1.23)	1.63 (1.00, 2.30)
Density Estimates (Double-Sampling)	1.34 (0.32, 2.80)	3.64 (2.16, 5.20)	4.70 (2.81, 6.55)	3.64 (2.16, 5.20)	0.43 (0, 1.01)	0.83 (0.20, 1.63)	0.70 (0.25, 1.26)	1.65 (1.02, 2.34)
Density Estimates (Removal)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.90 (2.31, 17.01)
Raw population size estimate	235.3 (57.0, 492.1)	640.8 (380.3, 914.3)	826.3 (495.0, 1150.7)	640.8 (380.3, 914.3)	76.1 (0, 177.4)	146.3 (35.1, 286.7)	123.1 (43.5, 221.0)	291.3 (179.9, 411.6)
Population Size (Double-sampling)	240.0 (58.1, 502.0)	653.6 (387.9, 932.6)	842.8 (504.9, 1173.7)	653.6 (387.9, 932.6)	77.6 (0, 181.0)	149.2 (35.8, 292.5)	125.6 (44.4, 225.4)	297.1 (183.5, 419.9)
Population Size (Removal Modeling)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	699.8 (413.8, 3048.1)
Total								
Population Size (Double-sampling) / (Removal)	262.0	653.6	842.8	653.6	77.6	274.7	209.3	363.1 / 758.4

Habitat Use

The vast majority of Bell's Vireos were found in desert riparian habitat, with disturbed agriculture and mesquite/acacia being secondary habitats (Figure 4). Willows and mesquite provide their primary habitat within the arid West, but a variety of woody riparian vegetation, including tamarisk are also used (Kus et al. 2010). Based on our data, the species appears to be a clear riparian habitat specialist, and we suspect that both secondary habitats are less suitable, not only because of the lower use overall, but also because breeding densities in these habitats was lower than in riparian (Table 7). Bell's Vireo has also been reported to prefer large habitat patches (Kus et al. 2010), which emphasizes the need to preserve and enhance large riparian patches in Clark County, where most riparian patches are currently relatively small.

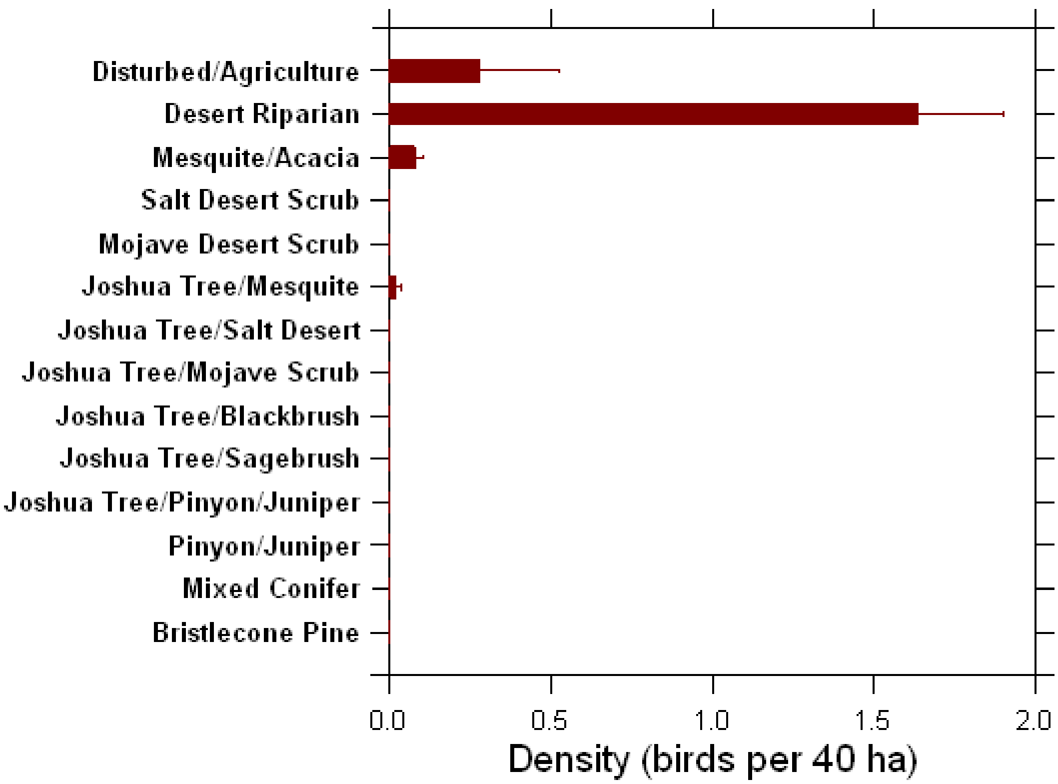

Figure 4. Estimated density (mean and standard error) of the Bell's Vireo at survey points in Clark County dominated by each GIS habitat grouping from the Clark County habitat map (Heaton et al. 2011).

Statistical Habitat Model

When comparing estimated densities of Bell's Vireo at point count locations where different habitat features were present or absent, we found that densities were significantly higher in plots that had a road within 400 m, developments within 1000 m, surface water within 100 m and within 1000 m, having a dry wash present, deciduous trees and riparian shrubs present, but coniferous trees absent (Table 7). Densities were also higher in grazed plots than in ungrazed areas. We interpret the presence of these land disturbances, such as grazing and nearby roads and developments, in plots with high Bell's Vireo densities, not as a preference or even a specific disturbance tolerance, but rather simply that most or all of its preferred habitat is located near such disturbances. According to our analysis, several dominant plant species within the plot were avoided or selected by Bell's Vireo; specifically, Joshua tree and other *Yucca* species, acacia, pinyon pine and juniper, creosote, cliffrose, and sagebrush were less likely to be in plots with high vireo density than in plots where the species had low densities, while cottonwood, tamarisk, and mesquite were more likely to be present in high-density plots (Table 8).

Table 8. Comparison of estimated densities (birds per 40 ha) for Bell's Vireo, with and without selected habitat or landscape elements, along with p-values from ANOVA analyses.

	Absent	Present	ANOVA p-value
Roads within 400 m	0.05	0.26	0.00
Development 1000 m	0.13	0.34	0.02
Water within 100 m	0.04	1.41	0.00
Water within 1000 m	0.01	0.91	0.00
Dry Wash within 100 m	0.34	0.07	0.00
Trees within 100 m	0.19	0.14	0.43
Deciduous trees	0.08	0.87	0.00
Coniferous trees	0.20	0.02	0.02
Trees within 1000 m	0.10	0.18	0.26
Riparian Shrub within 100 m	0.01	1.09	0.00
Grazing within 100 m	0.11	0.42	0.00
Tall cholla within 100 m	0.19	0.04	0.05
Mistletoe within 100 m	0.13	0.22	0.21
From plant species lists (all within 100 m):			
Joshua Tree	0.22	0.00	0.00
Mojave Yucca	0.22	0.01	0.00
Acacia	0.21	0.01	0.01
Mesquite	0.06	1.05	0.00
Pinyon Pine	0.19	0.00	0.03
Juniper	0.19	0.00	0.02
Willow	0.08	2.55	0.00
Tamarisk	0.05	1.17	0.00
Creosote	0.29	0.06	0.00
Saltbush	0.16	0.14	0.85
Cliffrose	0.17	0.00	0.10
Sagebrush	0.18	0.00	0.04
Cottonwood	0.15	0.76	0.01

In our logistic regression analysis on used and unused plot for Bell's Vireo, we found that the plots where the species were significantly lower in elevation (mean = 1,454 ft), had lower plant density at ground height, but higher plant density at the shrub level (1.5-4 m height), had no Joshua trees, but a higher proportion of mesquite and tamarisk than sites where the species was absent (Table 8). Furthermore, sites with Bell's Vireo detections had no blackbrush, pinyon pine, or juniper, and they had a significantly lower proportion of creosote than sites with no Bell's Vireo detections.

Table 8. Logistic regression results for habitat models predicting Bell's Vireo occurrence (detected on 16 points, with mean and standard error of the variables at points with or without detections the species. All variables except elevation are derived from point-centered-quarter plotless sampling.

	Species not detected	Species detected	coefficient	p-value	R^2
Elevation in feet	3,468 ±40	1,454 ±55	-	0.00	0.23
Plant Density at 0 to 0.5 m height	4,373 ±189	1,395 ±424	+	0.02	0.04
Plant Density at 0.5 to 1.5 m height	1,126 ±40	1,410 ±531	+	0.37	0.00
Plant Density at 1.5 to 4 m height	182 ±10.6	693 ±244	+	0.00	0.04
Plant Density at 4 to 10 m height	13.9 ±1.6	29.9 ±9.2	+	0.23	0.00
Plant Density at > 10 m height	5.1 ±2.8	0.29 ±0.21	-	0.57	0.00
Joshua Tree (proportion of density)	0.054 ±0.003	0.00	-	0.00	0.06
Mojave Yucca (proportion of density)	0.032 ±0.002	0.004 ±0.004	-	0.07	0.03
Acacia (proportion of density)	0.034 ±0.002	0.020 ±0.014	-	0.33	0.00
Mesquite (proportion of density)	0.012 ±0.001	0.076 ±0.022	+	0.00	0.04
Tamarisk (proportion of density)	0.035 ±0.003	0.089 ±0.038	+	0.00	0.04
Creosote (proportion of density)	0.196 ±0.005	0.020 ±0.009	-	0.00	0.10
Saltbush (proportion of density)	0.033 ±0.003	0.015 ±0.007	-	0.38	0.00
Blackbrush (proportion of density)	0.036 ±0.002	0.00	-	0.00	0.04
Pinyon Pine (proportion of density)	0.045 ±0.003	0.00	-	0.00	0.04
Juniper (proportion of density)	0.024 ±0.001	0.00	-	0.00	0.04

Bell's Vireos breed in riparian areas dominated by willow, cottonwood, riparian mesquite, or tamarisk (Kus et al. 2010), and in all these habitat types, the presence of dense understory is the crucial habitat feature. The most critical structural component of Least Bell's Vireo habitat in a California study was a dense shrub layer 0.6-3.0 m above ground (Franzreb 1989). This is similar to the results of our study where the most significant structural component was in the 1.5 to 4 m height vegetation layer. Research also consistently shows that nest success increases as understory vegetation becomes denser (Averill-Murray et al. 1999). In one restoration project on the San Pedro River in Arizona, vireo abundance more than doubled within four years of cattle removal, and resulting increases in understory density (Krueper et al. 2003).

The Bell's Vireo appears to have adapted to tamarisk as a breeding substrate, and several studies demonstrated that nesting densities in tamarisk and native riparian vegetation are similar. On the San Pedro River in Arizona, Bell's Vireos had similar densities in tamarisk and native vegetation, although nest productivity was higher in native vegetation (Brand et al. 2010). Along the lower Colorado River in Arizona, 52% of 129 nests occurred in the introduced tamarisk and 28% in mesquite (Averill-Murray et al. 1999), similar to results in other studies (Kus et al. 2010)

Similar to our studies (GBBO 2010), surface water was reported as an important element of Bell's Vireo habitat in other studies (Kus et al. 2010). This may be one reason why densities are often lower in desert wash than in riparian bottomland, as was the case in our findings. In addition to understory density and water, patch size is also important. Vireos were more abundant and reproduced more successfully in larger cottonwood and willow patches (>160 ha) in the lower Colorado River valley (Lynn 1996). Bell's Vireos are also sensitive to urbanization, decreasing to one quarter of the density in urban habitats even when vegetation was still native, and disappearing when it was not (Mills et al. 1989).

Observed Actual Distribution

Bell's Vireos were recorded in most riparian areas of Clark County (Figure 5). Because we wanted to present the best cumulative knowledge of their breeding distribution in the county, we included the breeding bird atlas data from Floyd et al. (2007), a project that was also co-sponsored by the Clark County MSHCP. It is encouraging that the species appears to be widely distributed throughout the county, including in small riparian systems, which indicates that even small conservation projects, such as spring restoration and enhancement, will readily benefit this species.

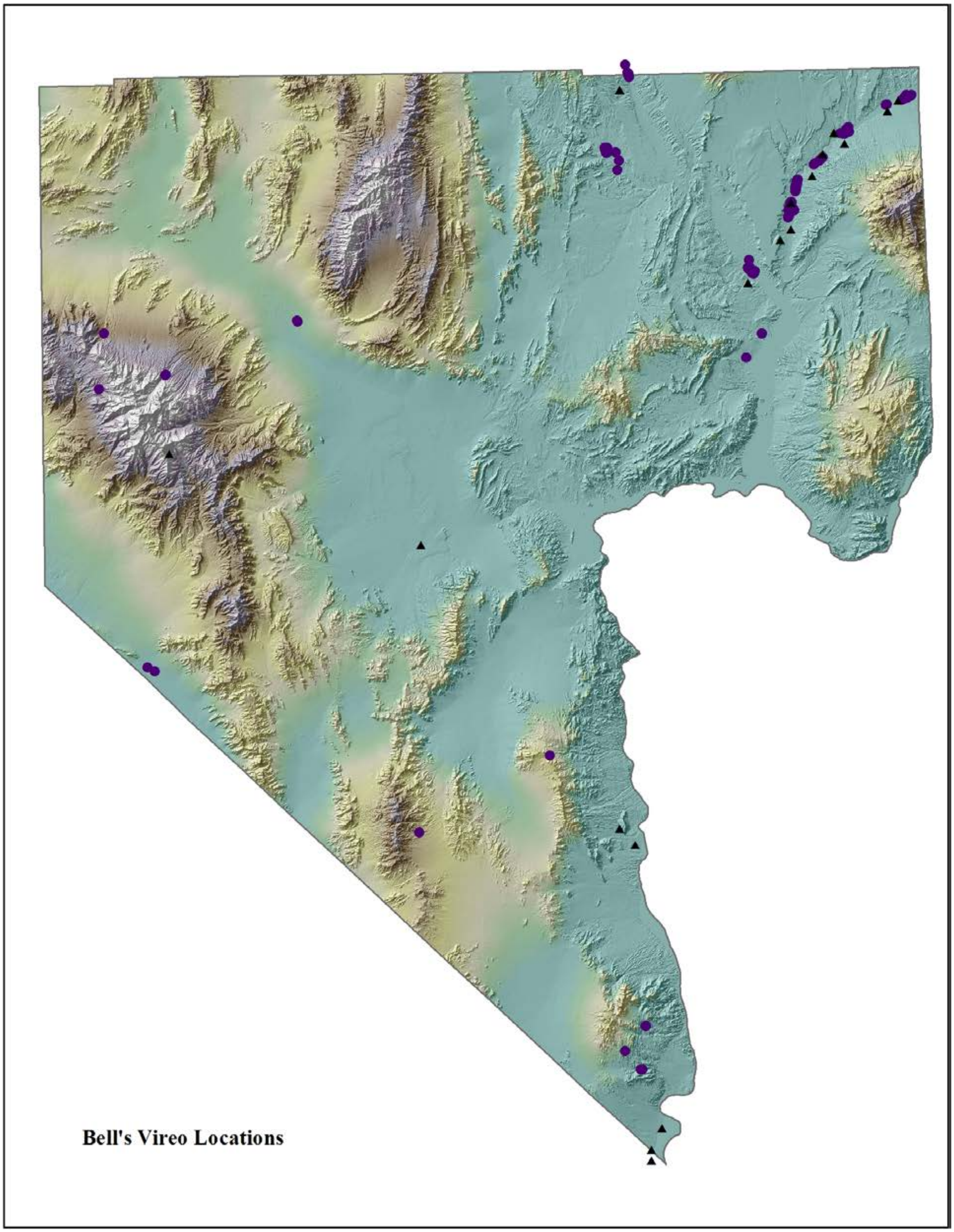

Figure 5. Bell's Vireo locations within Clark County. Circles indicate records at Nevada Bird Count transect points (2003-2013); triangles indicate Breeding Bird Atlas records (1998-2000).

Spatial Habitat Models

The predicted distribution and density map, which is based on an extrapolation from observed densities in different habitat types, indicates that major strongholds for the Bell's Vireo population of Clark County include the Muddy and Virgin rivers, part of the Las Vegas Wash system, and the Lower Colorado River reaches of the southern tip of Clark County (Figure 6). Local densities might also be high in smaller patches that are poorly visible on this map, as this species appears not to require particularly large patches to be present as a breeder. However, larger patches a most likely more suitable, both because they provide more abundant and consistently available resources to the birds and because they provide a large pool of potential mates.

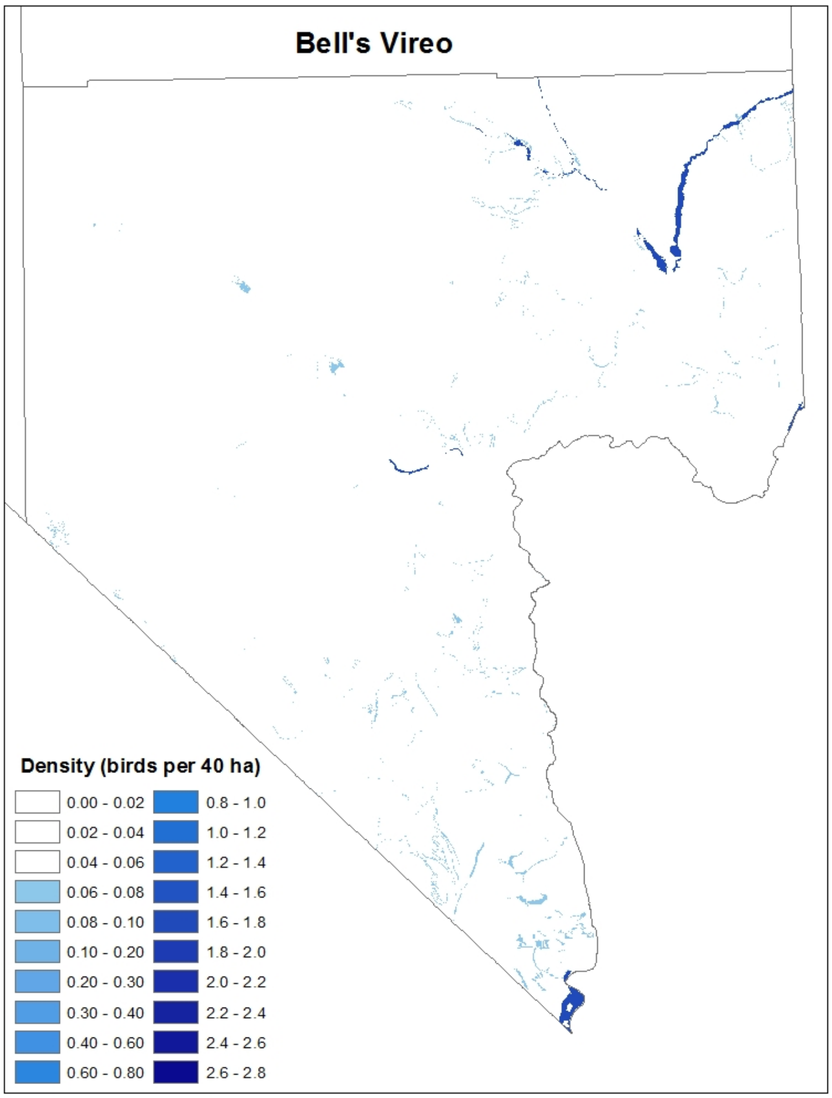

Figure 6. Predicted distribution of Bell's Vireo in Clark County. Mapped values represent the predicted density of the Bell's Vireo in each GIS habitat category from the Clark County habitat map (Heaton et al. 2011).

In a different projection of predicted densities across the whole Mojave portion of Nevada, Bell's Vireos appear a little more evenly distributed across the landscape, but indicating largely the same population strongholds as the projections just based on Clark County spatial data (Figure 7). As with other riparian species, Bell's Vireo populations are difficult to project accurately because of the inherent problems associated with accurately mapping riparian areas. Therefore, the user of all predictive maps presented in this report should be cautioned that these only represent projections based on the best current mapping products and bird population data, and actual local habitat conditions will always be the most important predictor of whether the species is present.

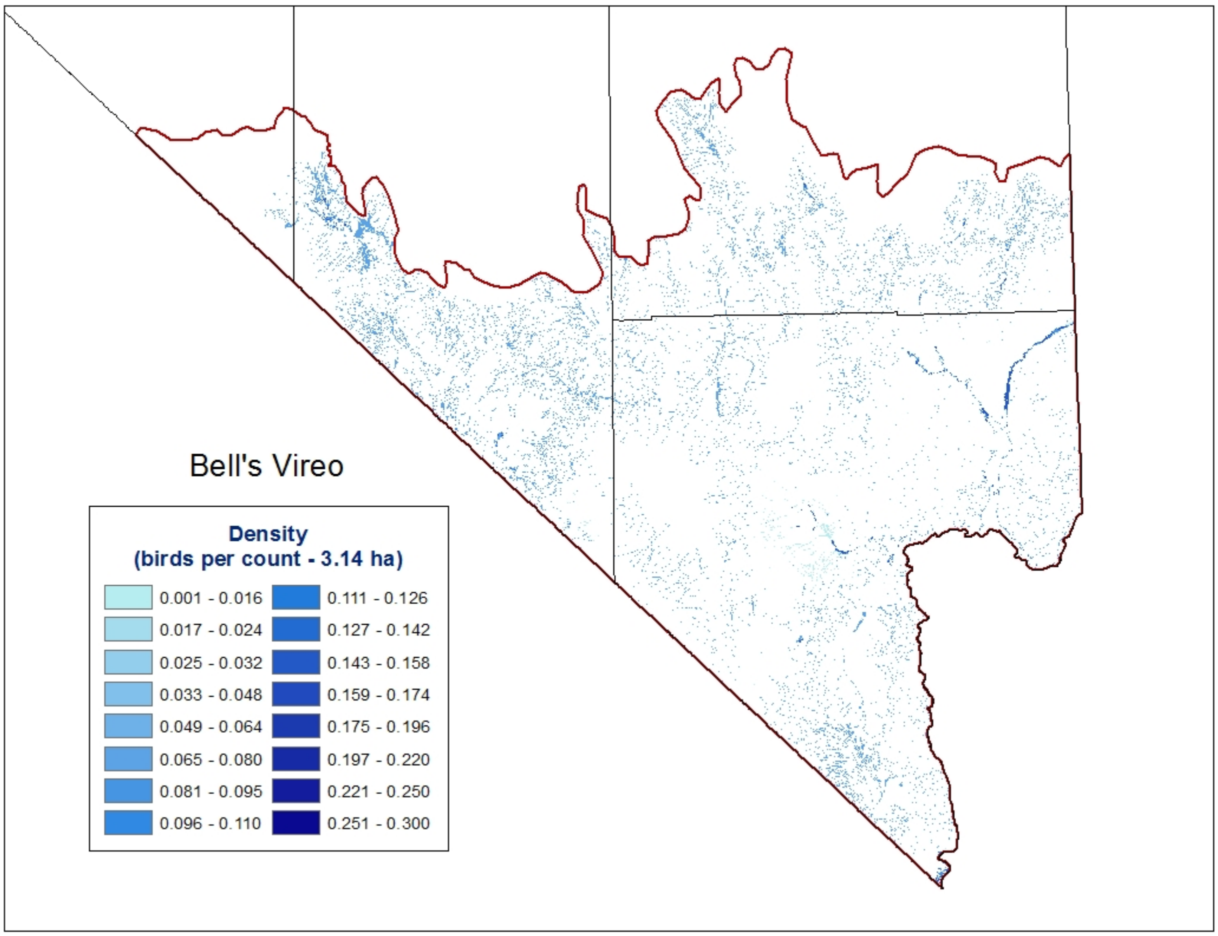

Figure 7. Predicted distribution of Bell's Vireo throughout the Mojave Desert region of Nevada. Mapped values are derived from the mean abundance per point count in habitat categories according to Provencher and Anderson (2011).

Blue Grosbeak (Covered Species)

Photo and Rights: Martin Meyers

Conceptual Model

Blue Grosbeaks occur primarily in riparian areas of the Mojave region, but they stand out from the other focal species in their apparent tolerance of fairly degraded habitat conditions. While they may tolerate some habitat degradation, they are still considered a riparian specialist in a sense that they are rarely observed far from riparian or riparian-like habitat patches. Therefore, in our conceptual model of what drives their breeding populations, we identified all major stressors that reduce riparian habitat cover and quality, with similar expected population responses as we identified for Bell’s Vireo (Figure 8). Blue Grosbeaks are also a migratory species, so in Clark County, habitat effects on their populations will only be observed, and thus can only be managed for, in their breeding grounds.

Ecological Stressors → **Important Habitat Effects** → **Expected Blue Grosbeak Responses**

Ecological Stressors

Structural Change

- Habitat conversion: urbanization, energy development, transportation corridors, catastrophic fires
- River channelization, impoundment, floodplain conversion to agriculture
- Recreational facilities and off-road vehicle recreation

Change in Processes

- Introduced weeds
- Climate change
- Drought
- Change in fire regime
- Ungulate grazing
- Change in river flow regimes and groundwater tables

Important Habitat Effects

Habitat Loss

- Fragmentation and loss of woodlands
- Loss of shrub cover

Habitat Degradation

- Water stress/mortality of shrubs
- Loss of native shrub and wetland covers
- Decreased water availability in soils and floodplain wetlands
- Decreased wetland invertebrate populations

Expected Blue Grosbeak Responses

Nesting

- Loss of suitable nest sites
- Increased territory sizes
- Increased nest failure rate
- Decreased reproductive output

Survival

- Longer travel for foraging
- Reduced foraging success
- Increased unpredictability of prey
- Stress response to loss of water and thermal shelters

Population

- Reduced recruitment of young
- Reduced site fidelity
- Decreased population size
- Fragmented population
- Increased population fluctuations

Recommendations for the Development of Indicators of Blue Grosbeak Population Effects:
Baseline data on territory sizes, locations, nests (and nest success, if possible) in randomly selected occupied sites in Clark County. Research on prey use and availability to develop a simple indicator prey species monitoring plan. Long-term population monitoring of Blue Grosbeaks.

Figure 8. Blue Grosbeak conceptual habitat model, Clark County.

Density and Population Estimates

During our surveys, Blue Grosbeaks were found most reliably in lowland riparian transects, and secondarily in agriculture transects (Table 9). A record of a Blue Grosbeak in a Pinyon-Juniper transect containing some riparian habitat resulted in spuriously high population estimates for pinyon-juniper habitats. We found higher densities of Blue Grosbeaks in lowland riparian habitats (1.81 bird detections/40 ha) than in agricultural areas (0.23 bird detections/40 ha). The confidence intervals for the agricultural estimates included zero. Lowland riparian density estimates using removal modeling were similar to those using the raw data; however, the double-sampling suggested higher densities in lowland riparian habitats (6.21 birds/40 ha), such that the confidence intervals between the double-sampling estimates and the raw estimates did not overlap.

Our uncorrected density estimates are lower than those found by Brand et al. (2010) along the San Pedro River (Arizona) within riparian and mesquite habitats, where they recorded approximately 2.7 to 9.6 birds/40 ha. Rosenberg (1991) reported breeding densities of 4 to 6 birds/40 ha. Krueper et al. (2003) reported densities of 4.7 to 11.6 birds/40 ha in a variety of other southwestern sites, and Anderson and Ohmart (1977) reported densities of 5.5 to 10.3 birds/40 ha along the lower Colorado River. Therefore, the current contribution of Clark County populations to the global population of Blue Grosbeaks is estimated to be low.

The Blue Grosbeak population estimate for the agricultural stratum is relatively similar using both correction methods, and for the lowland riparian stratum, the difference in density estimates between the removal and double-sampling methods resulted in large differences in the overall population estimates for the county. Using the double-sampling results for the agriculture and lowland riparian strata, we estimated 1,164 Blue Grosbeaks, while using removal modeling, we estimated 436 individuals to be in the county.

Annual population estimates for Blue Grosbeak, corrected with double-sampling, varied over the six years of the study. With the exception of one year that had an estimated 130 individuals, most years had an estimated 766 to 1192 individuals and quite consistent confidence intervals.

Table 9. Estimated density and population size of Blue Grosbeak in Clark County by year and habitat stratum, 2008-2013.

Stratum	2008	2009	2010	2011	2012	2013	2012-2013	Overall (2003-2013)
Agriculture								
Raw density of detections	1.91 (1.27, 2.55)		0.64 (0, 1.27)					0.23 (0, 0.46)
Density Estimates (Double-Sampling)	6.53 (4.35, 8.71)		2.18 (0, 4.35)					0.77 (0, 1.57)
Density Estimates (Removal)	N/A		N/A					0.92 (0.72, 2.30)
Raw population size estimate	129.2 (86.1, 172.3)		43.1 (0, 86.1)					15.3 (0, 31.0)
Population Size (Double-sampling)	441.9 (294.6, 589.4)		147.3 (0, 294.6)					52.2 (0, 106.0)
Population Size (Removal Modeling)	N/A		N/A					62.0 (48.9, 156.0)
Lowland Riparian								
Raw density of detections	1.79 (0.52, 3.22)	1.53 (0.64, 2.65)	0.21 (0, 0.50)	1.53 (0.64, 2.65)	1.25 (0.12, 2.69)	1.94 (0.87, 3.22)	1.74 (0.85, 2.72)	1.81 (1.12, 2.57)
Density Estimates (Double-Sampling)	6.12 (1.77, 11.02)	5.23 (2.18, 9.07)	0.73 (0, 1.69)	5.23 (2.18, 9.07)	4.27 (0.40, 9.19)	6.65 (2.97, 11.01)	5.95 (2.90, 9.30)	6.21 (3.84, 8.79)
Density Estimates (Removal)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.09 (1.57, 5.41)
Raw population size estimate	320.9 (92.7, 577.6)	273.94 (114.2, 475.4)	38.0 (0, 88.7)	273.9 (114.2, 475.4)	224.0 (21.1, 481.7)	348.5 (155.6, 576.7)	311.7 (152.1, 487.5)	325.2 (201.4, 460.4)
Population Size (Double-sampling)	1097.4 (316.9, 1975.4)	936.9 (390.4, 1626.0)	130.1 (0, 303.4)	936.9 (390.4, 1626.0)	765.9 (72.3, 1647.5)	1192.0 (532.0, 1972.3)	1066.2 (520.4, 1667.1)	1112.1 (688.9, 1574.5)
Population Size (Removal Modeling)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	374.3 (280.6, 970.3)

Stratum	2008	2009	2010	2011	2012	2013	2012-2013	Overall (2003-2013)
Pinyon-Juniper								
Raw density of detections						0.13 (0, 0.40)	0.08 (0, 0.24)	0.06 (0, 0.17)
Density Estimates (Double-Sampling)						0.45 (0, 1.36)	0.28 (0, 0.84)	0.20 (0, 0.59)
Raw population size estimate						398.7 (0, 1196.3)	245.3 (0, 736.4)	172.4 (0, 517.0)
Population Size (Double-sampling)						1363.4 (0, 4091.3)	839.0 (0, 2518.5)	589.6 (0, 1768.1)
Total								
Population Size (Double-sampling) / (Removal)	1539.3	936.9	277.4	936.9	765.9	2555.4	1905.2	1753.9 / 436.3

Habitat Use

Blue Grosbeak is a riparian species that occurs in areas with dense ground cover and varying shrub densities (Cartron 2013) and also in sites with a few scattered trees, such as in the Virgin River Valley (Lowther and Ingold 2011). Unlike the other riparian focal species, Blue Grosbeaks have fairly generalized habitat requirements. Often found in riparian edge habitats (White 1988), they also readily use tamarisk. For instance, in their studies at the Bill Williams River and Cibola National Wildlife Refuges, van Riper et al. (2008) found Blue Grosbeaks in increased numbers at sites with increased tamarisk. Blue Grosbeaks in Clark County are perhaps the most tolerant of degraded riparian habitats of the nine MSHCP species studied in this project. In Clark County, they almost exclusively use riparian settings (Figure 9), and they are often found in sites that are infested with tamarisk, interrupted by infrastructure, or in early-successional riparian woodlands after flood events (which likely represents their historic habitat association). The species is strongly associated with riparian and transitional shrubs, such as willow, tamarisk, mesquite, and even the more drought-tolerant species of the floodplain edge. During breeding, it requires terrestrial invertebrates that are generated by the riparian woodlands and wetlands in or near its territory. Nesting occurs in riparian or transitional shrub thickets.

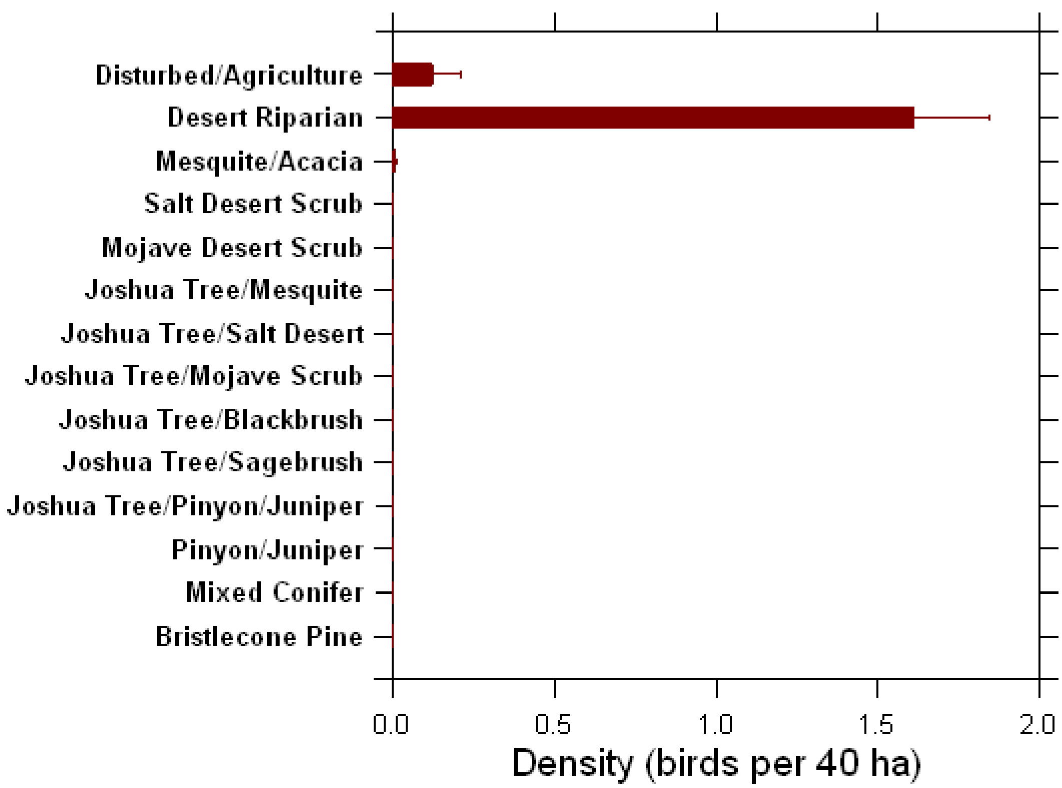

Figure 9. Estimated density (mean and standard error) of the Blue Grosbeak at survey points in Clark County dominated by each GIS habitat grouping, from the Clark County habitat map (Heaton et al. 2011).

Statistical Habitat Model

Estimated densities of Blue Grosbeaks in Clark County were significantly higher in plots with development within 1000 m, surface water within 100 m and 1000 m, deciduous trees and riparian shrubs within the plot, trees within 1000 m, and grazing within the plot, than in plots that did not have these features (Table 10). Estimated densities were lower in plots that had a dry wash, cholla cactuses, or mistletoe present within the plot. When reviewing dominant plant species of the region, Blue Grosbeaks had higher estimated densities in plots that had no Joshua tree, other *Yucca* species, acacia, or creosote present, but they had higher estimated densities when mesquite, tamarisk, or cottonwood were present in the plot (Table 10).

Table 10. Comparison of estimated densities (birds per 40 ha) for Blue Grosbeak, with and without selected habitat or landscape elements, along with p-values from the ANOVA tests.

	Absent	Present	ANOVA p-value
Roads within 400 m	0.14	0.19	0.45
Development 1000 m	0.03	0.92	0.00
Water within 100 m	0.06	1.32	0.00
Water within 1000 m	0.00	0.99	0.00
Dry Wash within 100 m	0.39	0.07	0.00
Trees within 100 m	0.19	0.15	0.56
Deciduous trees	0.08	0.89	0.00
Coniferous trees	0.20	0.04	0.05
Trees within 1000 m	0.03	0.22	0.01
Riparian Shrub within 100 m	0.03	1.05	0.00
Grazing within 100 m	0.12	0.44	0.00
Tall cholla within 100 m	0.22	0.00	0.01
Mistletoe within 100 m	0.21	0.05	0.04
From plant species lists (all within 100 m):			
Joshua Tree	0.24	0.00	0.00
Mojave Yucca	0.24	0.00	0.00
Acacia	0.22	0.02	0.01
Mesquite	0.11	0.65	0.00
Pinyon Pine	0.19	0.04	0.10
Juniper	0.20	0.03	0.07
Willow	0.11	2.01	0.00
Tamarisk	0.02	1.54	0.00
Creosote	0.30	0.08	0.00
Saltbush	0.15	0.23	0.36
Cliffrose	0.19	0.00	0.10
Sagebrush	0.18	0.07	0.23
Cottonwood	0.12	2.91	0.00

Our logistic regression results show that plots used by Blue Grosbeaks were significantly lower in elevation (mean elevation of Blue Grosbeak sites = 1,479 ft), had higher plant densities at shrub level (0.5 – 4 m height), had no Joshua tree, Mojave yucca, acacia, or blackbrush, but a higher proportion of mesquite and tamarisk, and a lower proportion of creosote than did plots that were not used by Blue Grosbeaks (Table 11).

Table 11. Logistic regression results for habitat models predicting Blue Grosbeak occurrence (detected on 15 points), with mean and standard error of the variables at points with or without detections the species. All variables except elevation are derived from point-centered-quarter plotless sampling.

	Species not detected	Species detected	coefficient	p-value	R^2
Elevation in feet	3,468 ±40	1,479 ±104	-	0.00	0.23
Plant Density at 0 to 0.5 m height	4,357 ±189	2,383 ±648	+	0.16	0.01
Plant Density at 0.5 to 1.5 m height	1,117 ±40	1,863 ±561	+	0.02	0.01
Plant Density at 1.5 to 4 m height	185 ±10.7	523 ±223	+	0.00	0.02
Plant Density at 4 to 10 m height	14.1 ±1.6	17.4 ±7.2		0.78	0.00
Plant Density at > 10 m height	5.1 ±2.8	0.28 ±0.20	-	0.57	0.00
Joshua Tree (proportion of density)	0.054 ±0.003	0.00	-	0.00	0.06
Mojave Yucca (proportion of density)	0.032 ±0.002	0.00	-	0.00	0.05
Acacia (proportion of density)	0.035 ±0.002	0.00	-	0.00	0.05
Mesquite (proportion of density)	0.012 ±0.001	0.074 ±0.025	+	0.00	0.04
Tamarisk (proportion of density)	0.033 ±0.003	0.276 ±0.044	+	0.00	0.11
Creosote (proportion of density)	0.196 ±0.005	0.023 ±0.011	-	0.00	0.10
Saltbush (proportion of density)	0.033 ±0.003	0.036 ±0.019		0.90	0.00
Blackbrush (proportion of density)	0.036 ±0.002	0.00	-	0.00	0.04
Pinyon Pine (proportion of density)	0.045 ±0.003	0.001 ±0.001	-	0.26	0.03
Juniper (proportion of density)	0.024 ±0.001	0.003 ±0.003	-	0.11	0.02

The Blue Grosbeak has been described as a habitat generalist in other studies, as well, as it readily nests in the exotic tamarisk, in orchard trees, or in native willow/cottonwood habitat (e.g., Cartron 2013). Blue Grosbeaks are riparian edge species, occurring at forest/field edges or at forest/gravel-bar interfaces (Lowther and Ingold 2011). In a southern Arizona study they preferred nesting in sycamores (Powell and Steidl 2002), but our data indicate that large trees are not essential.

On the San Pedro River, Blue Grosbeaks had highest densities in mesquite, but tamarisk and grassland edge were not far behind (Brand et al. 2010). They have also been reported by some to be even more abundant in tamarisk than native shrubs (e.g., van Riper et al. 2008), and they were not affected by patch sizes on the lower Colorado River (Lynn 1996).

Observed Actual Distribution

Our combined records from the past 15 years of surveys indicate that the Blue Grosbeak occurs in most large and small riparian areas, including spring outflows, of Clark County (Figure 10). One potentially interesting pattern we observe in the distribution of records is that the latest surveys (past 10 years) produced primarily records in central and northern Clark County, while we failed to detect the species in the southern half of the county. At least occasional records from the southern half of the county were reported during the breeding bird atlas years of 1997-2000 (Floyd et al. 2007). However, from other surveys we have been conducting along the lower Colorado River we know that the species also breeds south of the Nevada border.

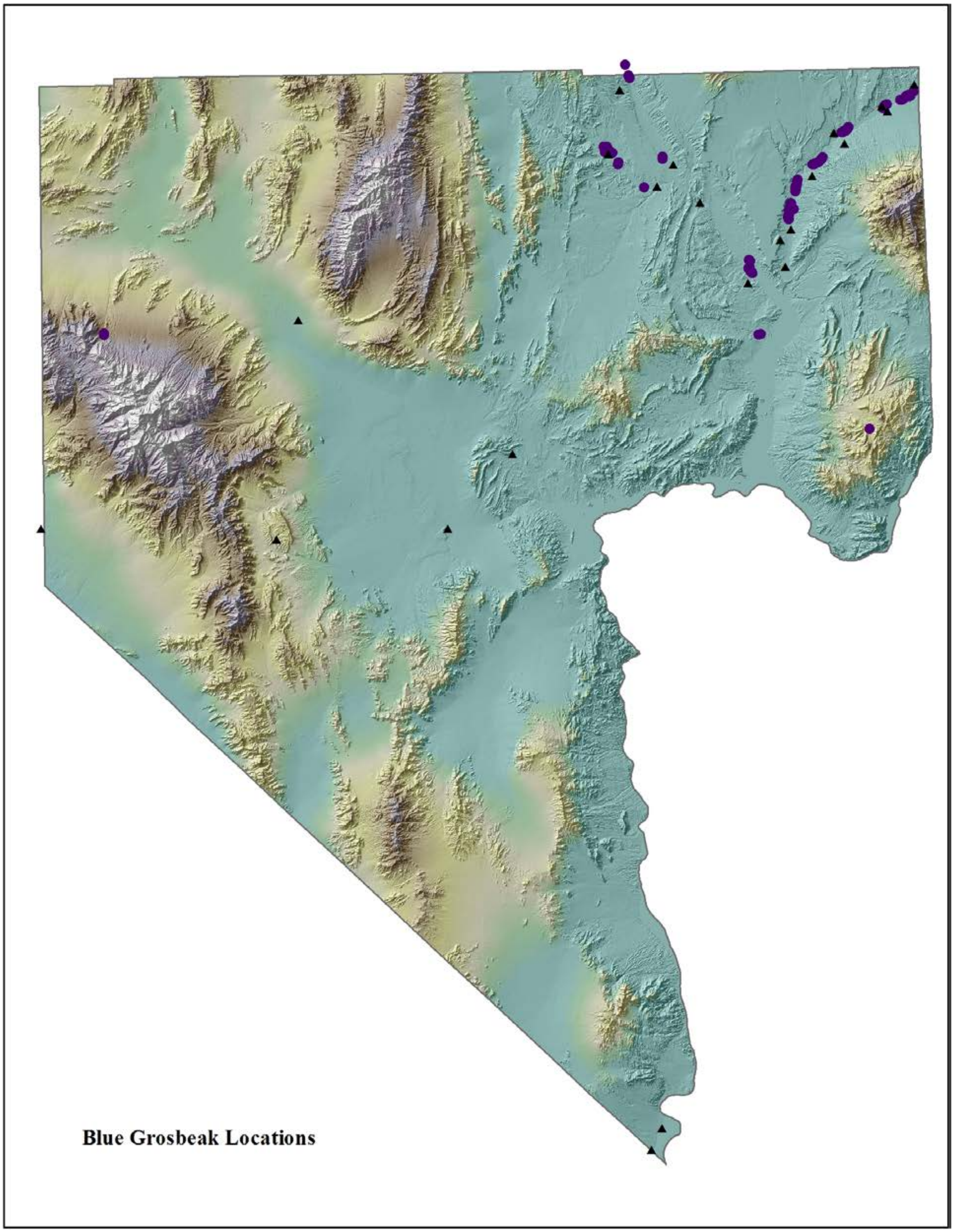

Figure 10. Blue Grosbeak locations within Clark County. Circles indicate records at Nevada Bird Count transect points (2003-2013); triangles indicate Breeding Bird Atlas records (1998-2000).

Spatial Habitat Models

The predicted density distribution of Blue Grosbeak throughout Clark County looks very similar to that of Bell's Vireo, most likely because they are both riparian habitat specialists (Figure 11). Strongholds of Blue Grosbeak populations are predicted at the Muddy and Virgin rivers, but the riparian areas along the lower Colorado River at the southern tip of the county are also predicted to be highly suitable based on available habitats.

The other spatial data set we used that covers some of the surrounding regions shows a slightly more generous predicted density distribution throughout Clark County (Figure 12), most likely because it takes into account several habitat condition classes in which Blue Grosbeak occasionally occurs. As with all highly habitat-specialized species, actual local occurrences of Blue Grosbeaks depend most importantly on whether suitable riparian habitat is available at a given location. Therefore, we consider the second spatial model to be somewhat of an overestimate of the actual areas that are suitable for Blue Grosbeak.

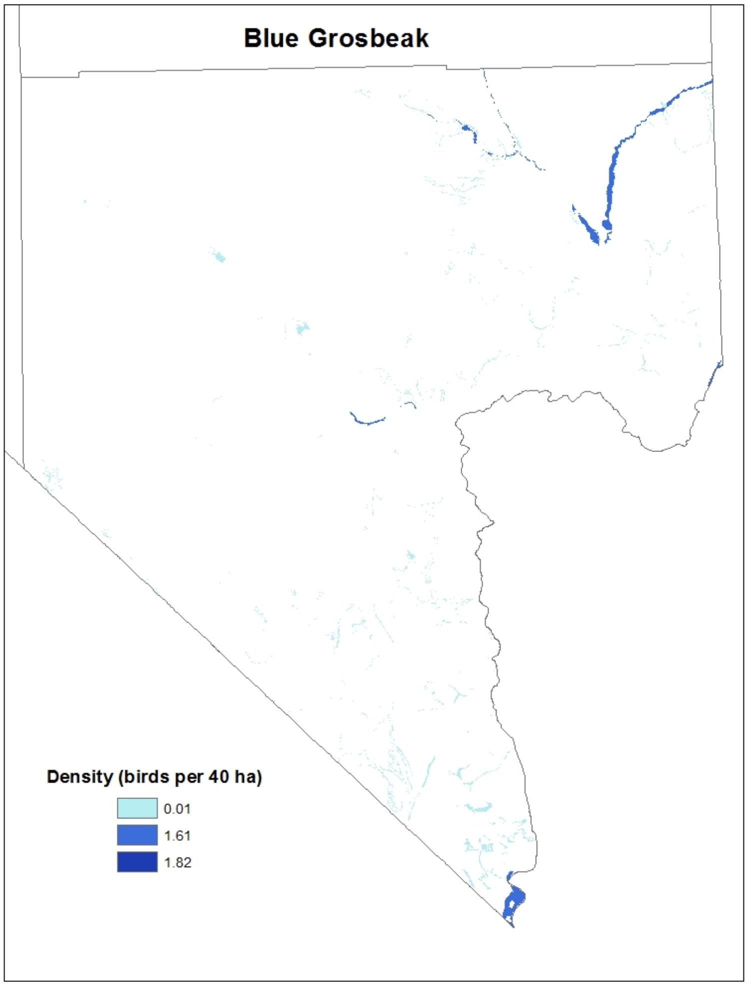

Figure 11. Predicted distribution of Blue Grosbeak in Clark County. Mapped values represent the predicted density of the Blue Grosbeak in each GIS habitat category from the Clark County habitat map (Heaton et al. 2011).

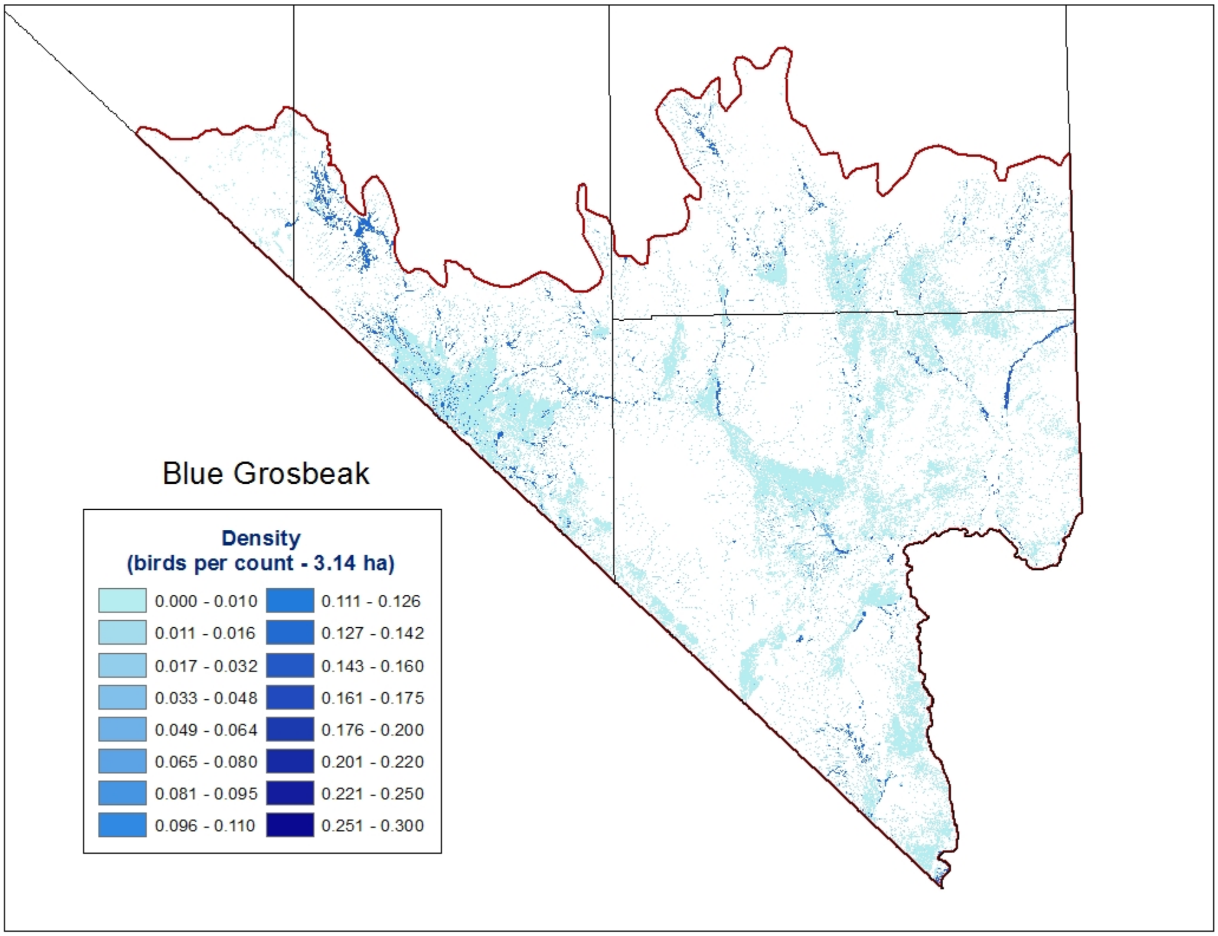

Figure 12. Predicted distribution of Blue Grosbeak in Clark County and the surrounding Mojave Desert region of Nevada. Mapped values are derived from the mean abundance per point count in habitat categories according to Provencher and Anderson (2011).

Phainopepla (Covered Species)

Photo and Rights: Scott Page

Conceptual Model

Phainopeplas are more specifically tied to mesquite and acacia with mistletoe infections than other focal species that show a more classic riparian-obligate pattern (Figure 13). In Clark County, much of the mesquite is associated with riparian areas, which is why most of our Phainopepla records are from riparian transects. However, the species appears to do equally well in mesquite-acacia setting that are distant from springs, streams and rivers. We therefore predict that the most important ecological stressors on the habitat of Phainopepla are those that directly or indirectly lead to loss or decreased vigor of their preferred woodland, mesquite-acacia. This loss may result from decreased surface and ground water resources, land uses that lead to the destruction of these woodlands, and other processes such as climate change. As with other species, the first signs of population stress are expected to be decreased reproductive activity and success, and ultimately, fragmentation of remaining populations that will result in decreased mating and territory establishment and higher population fluctuations.

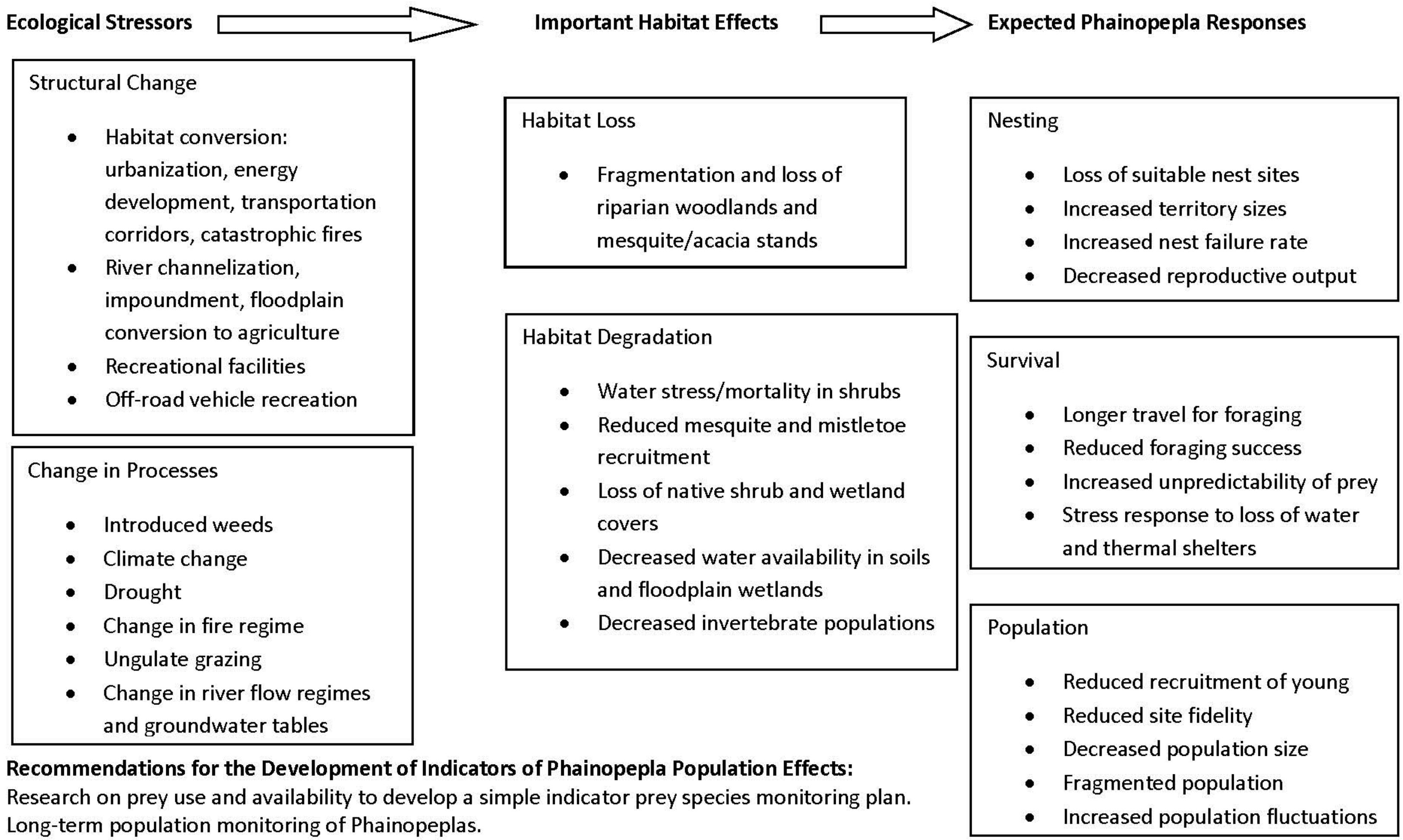

Figure 13. Phainopepla conceptual habitat model, Clark County.

Density and Population Estimates

Phainopeplas were found in their greatest densities in the lowland riparian stratum, followed closely by agriculture, and more distantly in mesquite-catclaw (Table 12). Interestingly, Phainopepla densities were estimated to be much higher in riparian-associated and agriculture-associated mesquite/acacia stands than in the ephemeral wash or bosque associated, dry upland stands that we had separated out as our "mesquite-catclaw" stratum. Scattered individuals were also recorded in Mojave scrub, Joshua tree, and salt desert, and for the latter two strata, confidence intervals for the uncorrected and double-sampling estimates included zero. In the lowland riparian stratum, we recorded 3.0 Phainopepla detections/40 ha, compared to 2.7 detections/40 ha in agriculture, and 0.90 detections/40 ha in mesquite-catclaw, but the confidence intervals for all three strata overlapped. Density estimates using removal modeling were similar to those using the raw data. In contrast, the double-sampling suggested higher densities in lowland riparian (8.6 birds/40 ha) and agricultural areas (7.8 birds/40 ha). The confidence levels also overlapped among the strata. In the remaining habitat types, raw density estimates, double-sampling estimates, and removal estimates were all fairly similar.

These results are similar to those found previously in the region. Crampton et al. (2011) reported a wide range of densities within the northeastern Mojave Desert (southern Nevada, southeastern California, and northwestern Arizona), ranging from 0.4 to 325.6 birds/40 ha. Chu and Walsberg (1999) indicated that they could range from being absent in apparently suitable habitat up to densities of 72 birds/40 ha. Krueper et al. (2003) recorded Phainopepla densities of approximately 0.2 -1.2 birds/40 ha along the San Pedro River in Arizona.

In agricultural transects, the density estimates were influenced by the small size of the stratum, so the estimated population sizes by double-sampling and removal analyses had overlapping confidence intervals. Differences in density estimates within lowland riparian transects were somewhat offset by the small stratum size, but still resulted in a large difference in the population estimates; the confidence intervals did not overlap. The mesquite-catclaw estimates and confidence intervals were similar between the two methods. In Mojave scrub, the raw population size estimate was midway between the removal model results and the double-sampling results. While the confidence intervals overlapped, those from the removal estimate were narrowest.

Annual population estimates, corrected with double sampling, were relatively consistent among the years of 2008 to 2012. In 2013, high detections on Joshua tree and Mojave scrub transects boosted the overall estimates. Overall, the removal analyses resulted in an estimated 5,502 Phainopeplas for Clark County, not including birds found in the secondary habitats Joshua tree and salt desert. The confidence intervals for the removal estimates tended to be narrower and did not include zero compared to the double-sampling and raw estimates. Double sampling resulted in an estimated 12,249 Phainopeplas for Clark County.

Table 12. Estimated density and population size of Phainopeplas in Clark County by year and habitat stratum, 2008-2013.

Stratum	2008	2009	2010	2011	2012	2013	2012-2013	Overall (2003-2013)
Agriculture								
Raw density of detections	0.32 (0, 0.64)	1.27 (0, 2.55)	3.18 (0, 6.37)	1.27 (0, 2.55)		5.45 (N/A)	3.64 (1.82, 5.46)	2.71 (0.53, 4.37)
Density Estimates (Double-Sampling)	0.91 (0, 1.82)	3.64 (0, 7.28)	9.10 (0, 18.21)	3.64 (0, 7.28)		15.61 (N/A)	10.40 (5.20, 15.61)	7.75 (1.51, 12.49)
Density Estimates (Removal)	N/A	N/A	N/A	N/A		N/A	N/A	2.16 (1.83, 2.50)
Raw population size estimate	21.5 (0, 43.1)	86.1 (0, 172.3)	215.4 (0, 430.7)	86.1 (0, 172.3)		369.2 (N/A)	245.1 (123.1, 369.2)	183.4 (35.7, 295.4)
Population Size (Double-sampling)	61.6 (0, 123.3)	246.4 (0, 492.9)	616.0 (0, 1231.9)	246.4 (0, 492.9)		1055.9 (N/A)	704.0 (352.0, 1056.0)	524.5 (102.2, 844.9)
Population Size (Removal Modeling)	N/A	N/A	N/A	N/A		N/A	N/A	146.4 (123.6, 169.2)
Joshua Tree								
Raw density of detections						0.25 (0, 0.76)	0.18 (0, 0.53)	0.12 (0, 0.37)
Density Estimates (Double-Sampling)						0.30 (0, 0.89)	0.21 (0, 0.62)	0.14 (0, 0.43)
Raw population size estimate						5049.3 (0, 15148.5)	3506.4 (0, 10528.6)	2475.1 (0, 7415.6)
Population Size (Double-sampling)						5857.1 (0, 17572.2)	4067.5 (0, 12213.2)	2871.1 (0, 8602.1)

Stratum	2008	2009	2010	2011	2012	2013	2012-2013	Overall (2003-2013)
Lowland Riparian								
Raw density of detections	4.00 (0.24, 7.99)	3.59 (0.45, 7.08)	3.49 (0.53, 7.58)	3.59 (0.45, 7.08)	1.60 (0.42, 3.06)	4.70 (0, 11.04)	3.03 (0.52, 6.79)	3.00 (0.95, 5.80)
Density Estimates (Double-Sampling)	11.43 (0.68, 22.86)	10.27 (1.29, 20.24)	9.98 (1.52, 21.67)	10.27 (1.29, 20.24)	4.59 (1.21, 8.77)	13.45 (0, 31.56)	8.67 (1.50, 19.42)	8.58 (2.72, 16.57)
Density Estimates (Removal)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.91 (2.69, 3.13)
Raw population size estimate	716.2 (42.8, 1432.4)	643.8 (80.8, 1268.4)	625.6 (95.2, 1357.7)	643.8 (80.8, 1268.4)	287.3 (76.0, 549.3)	842.5 (0, 1977.6)	543.3 (94.1, 1217.0)	537.9 (170.8, 1038.5)
Population Size (Double-sampling)	2048.5 (122.5, 4096.7)	1841.2 (231.2, 3627.8)	1789.2 (272.2, 3883.0)	1841.2 (231.2, 3627.8)	821.8 (217.3, 1570.9)	2409.6 (0, 5655.9)	1553.8 (269.1, 3480.7)	1538.3 (488.5, 2970.2)
Population Size (Removal Modeling)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	521.0 (481.2, 560.9)
Mesquite-Catclaw								
Raw density of detections		1.27 (N/A)		1.27 (N/A)	0.82 (0, 1.73)	0.95 (0.32, 1.72)	0.90 (0.38, 1.49)	0.90 (0.39, 1.47)
Density Estimates (Double-Sampling)		1.48 (N/A)		1.48 (N/A)	0.95 (0, 2.00)	1.11 (0.37, 1.99)	1.04 (0.44, 1.73)	1.04 (0.45, 1.70)
Density Estimates (Removal)		N/A		N/A	N/A	N/A	N/A	0.93 (0.82, 1.05)
Raw population size estimate		647.9 (N/A)		647.9 (N/A)	416.5 (0, 879.3)	485.9 (161.8, 874.7)	455.6 (192.3, 759.2)	455.8 (196.4, 746.0)
Population Size (Double-sampling)		751.6 (N/A)		751.6 (N/A)	483.1 (0, 1020.0)	563.7 (187.7, 1014.7)	528.4 (223.1, 880.7)	528.7 (227.8, 865.3)
Population Size (Removal Modeling)		N/A		N/A	N/A	N/A	N/A	474.1 (416.3, 531.9)

Stratum	2008	2009	2010	2011	2012	2013	2012-2013	Overall (2003-2013)
Mojave Scrub								
Raw density of detections					0.07 (0, 0.22)	0.18 (0, 0.55)	0.13 (0, 0.37)	0.27 (0.01, 0.67)
Density Estimates (Double-Sampling)					0.09 (0, 0.26)	0.21 (0, 0.63)	0.16 (0, 0.43)	0.31 (0.01, 0.78)
Density Estimates (Removal)					N/A	N/A	N/A	0.22 (0.18, 0.26)
Raw population size estimate					1487.3 (0, 4468.0)	3612.1 (0, 10842.3)	2661.5 (0, 7327.5)	5367.0 (119.1, 13364.3)
Population Size (Double-sampling)					1725.3 (0, 5182.9)	4190.0 (0, 12577.1)	3087.4 (0, 8499.9)	6225.7 (138.2, 15502.6)
Population Size (Removal Modeling)					N/A	N/A	N/A	4360.8 (3566.7, 5154.8)
Salt Desert								
Raw density of detections								0.39 (0, 1.18)
Density Estimates (Double-Sampling)								0.45 (0, 1.36)
Raw population size estimate								483.0 (0, 1448.7)
Population Size (Double-sampling)								560.3 (0, 1680.5)
Total								
Population Size (Double-sampling) / (Removal)	2110.1	2839.2	2405.2	2839.2	3030.2	14076.4	9941.1	12248.6 / 5502.3

Habitat Use

Phainopeplas occur throughout Clark County in mesquite and acacia stands, near or away from riparian areas (Figure 14), where they are closely associated with desert mistletoe infections. In San Diego County, California, Phainopeplas were reported as absent from urban transects, and they were 32 times more abundant in core habitat patches compared with fragments (Crooks et al. 2004). They specialize on mesquite's mistletoe berries, which they consume throughout the year when available, and they often use the mistletoe clusters as nest sites. During breeding, the species requires insects or other invertebrates that are produced by a healthy mesquite-acacia stand and its understory plants. Given the species' specialization on mistletoes and mesquite-acacia, their overall habitat use pattern is surprisingly broad - in fact, it is the broadest set of habitat types used of the nine focal species. This is likely due to the fact that Phainopeplas naturally wander around the landscape before and after breeding, but of the riparian-associated focal species, they are also the most tolerant of uplands.

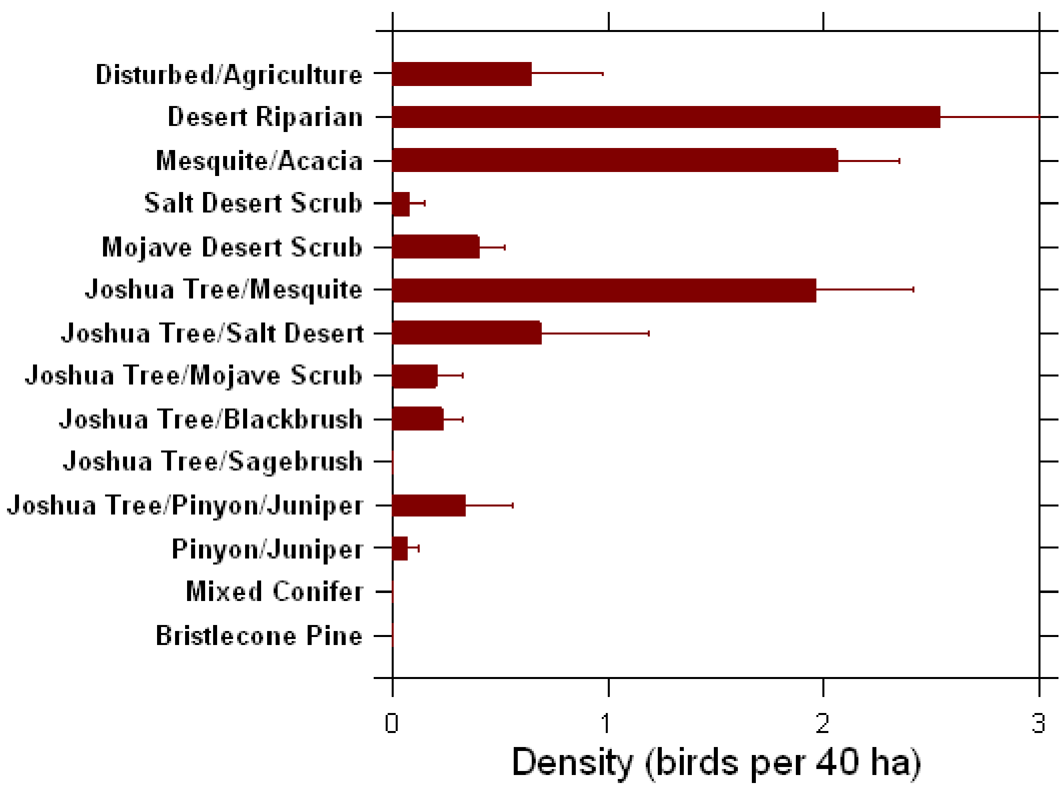

Figure 14. Estimated density (mean and standard error) of the Phainopepla at survey points in Clark County dominated by each GIS habitat grouping, from the Clark County habitat map (Heaton et al. 2011).

Statistical Habitat Model

Our vegetation surveys at survey points revealed that Phainopepla densities were significantly higher in plots where the following habitat features were present compared with plots where these were absent: roads within 400 m, development within 1000 m, surface water within 100 m and 1000 m, deciduous trees and riparian shrubs within the plot, trees within 1000 m, or mistletoe within the plot (Table 13). Phainopepla densities were lower in plots where coniferous trees were present than in plots where they were absent. Of the dominant plant species within the plots examined, Phainopepla densities were significantly higher when mesquite, acacia, tamarisk, or cottonwood were present than in plots where they were absent. Their densities were lower where Joshua tree, pinyon pine or juniper were present within the plot than if these were absent (Table 13). This statistical pattern confirms that Phainopepla, despite their broad habitat use across the landscape, appear to prefer riparian woodlands over other dominant vegetation types.

Table 13. Comparison of estimated densities (birds per 40 ha) for Phainopepla, with and without selected habitat or landscape elements, along with p-values from the ANOVA tests.

	Absent	Present	ANOVA p-value
Roads within 400 m	0.32	1.15	0.00
Development 1000 m	0.61	1.50	0.00
Water within 100 m	0.57	2.59	0.00
Water within 1000 m	0.54	1.76	0.00
Dry Wash within 100 m	0.94	0.66	0.08
Trees within 100 m	0.65	0.79	0.36
Deciduous trees	0.56	2.31	0.00
Coniferous trees	0.84	0.39	0.02
Trees within 1000 m	0.51	0.82	0.07
Riparian Shrub within 100 m	0.51	2.25	0.00
Grazing within 100 m	0.77	0.55	0.28
Tall cholla within 100 m	0.68	0.97	0.10
Mistletoe within 100 m	0.17	2.38	0.00
From plant species lists (all within 100 m):			
Joshua Tree	0.88	0.42	0.01
Mojave Yucca	0.71	0.82	0.50
Acacia	0.48	1.44	0.00
Mesquite	0.55	2.54	0.00
Pinyon Pine	0.83	0.26	0.00
Juniper	0.83	0.34	0.01
Willow	0.67	2.96	0.00
Tamarisk	0.67	1.39	0.01
Creosote	0.60	0.84	0.12
Saltbush	0.73	0.76	0.89
Cliffrose	0.77	0.44	0.17
Sagebrush	0.76	0.64	0.55
Cottonwood	0.67	4.71	0.00

In the logistic regression analyses, we found that plots where Phainopeplas were present were lower in elevation (mean elevation on Phainopepla plots = 2,718 ft), had lower plant densities at 4 – 10 m height, and had lower proportions of Joshua tree, creosote, blackbrush and juniper than did sites not used by the species (Table 14). Sites used by Phainopeplas also had higher proportions of acacia, mesquite, and saltbush than did unused sites.

Table 14. Logistic regression results for habitat models predicting Phainopepla occurrence (detected on 43 points), with mean and standard error of the variables at points with or without detections the species. All variables except elevation are derived from point-centered-quarter plotless sampling.

	Species not detected	Species detected	coefficient	p-value	R^2
Elevation in feet	3,481 ±42	2,718 ±101	-	0.00	0.03
Plant Density at 0 to 0.5 m height	4,412 ±196	3,017 ±489	-	0.07	0.03
Plant Density at 0.5 to 1.5 m height	1,133 ±41	1,105 ±202		0.87	0.00
Plant Density at 1.5 to 4 m height	192 ±11.8	180 ±33		0.80	0.00
Plant Density at 4 to 10 m height	15.0 ±1.7	2.62 ±0.77	-	0.03	0.02
Plant Density at > 10 m height	5.3 ±3.0	0.17 ±0.07	-	0.23	0.01
Joshua Tree (proportion of density)	0.055 ±0.003	0.016 ±0.005	-	0.00	0.03
Mojave Yucca (proportion of density)	0.031 ±0.002	0.029 ±0.005		0.76	0.00
Acacia (proportion of density)	0.029 ±0.002	0.101 ±0.013	+	0.00	0.07
Mesquite (proportion of density)	0.008 ±0.001	0.082 ±0.015	+	0.00	0.09
Tamarisk (proportion of density)	0.039 ±0.004	0.026 ±0.007	-	0.37	0.00
Creosote (proportion of density)	0.198 ±0.005	0.120 ±0.013	-	0.00	0.02
Saltbush (proportion of density)	0.033 ±0.003	0.042 ±0.010	+	0.40	0.00
Blackbrush (proportion of density)	0.037 ±0.002	0.010 ±0.005	-	0.01	0.02
Pinyon Pine (proportion of density)	0.047 ±0.003	0.002 ±0.001			
Juniper (proportion of density)	0.024 ±0.001	0.009 ±0.003	-	0.01	0.01

The Phainopepla is most abundant in desert riparian areas or along ephemeral washes or bosques. It is closely associated with desert mistletoe, which parasitizes arborescent legumes such as acacias and mesquite, which the Phainopepla uses for both foraging and nesting (Chu and Walsberg 1999). Our data also show this association with mistletoe to be the strongest habitat relationship of the species, along with its relationship with mesquite and acacia.

In one major study, Crampton et al. (2011) surveyed mesquite-acacia woodlands in the Mojave Desert of southern Nevada, southeastern California and northwestern Arizona, and found that mistletoe abundance was the primary factor in determining Phainopepla occupancy and density, followed by habitat fragmentation, while vegetation structure played only a minor role in predicting distribution and density. Phainopeplas are generally not found in urban or suburban areas (Chu and Walsberg 1999).

Observed Actual Distribution

As the Phainopepla's habitat use suggests, the species has a broader distribution across the landscape than the other riparian-associated focal species (Figure 15). The species is widely distributed throughout Clark County based on the past 15 years of survey records. The encouraging fact about this distribution is that it is likely that where appropriate habitats are preserved, enhanced and restored, this species will likely continue to be maintained across the landscape.

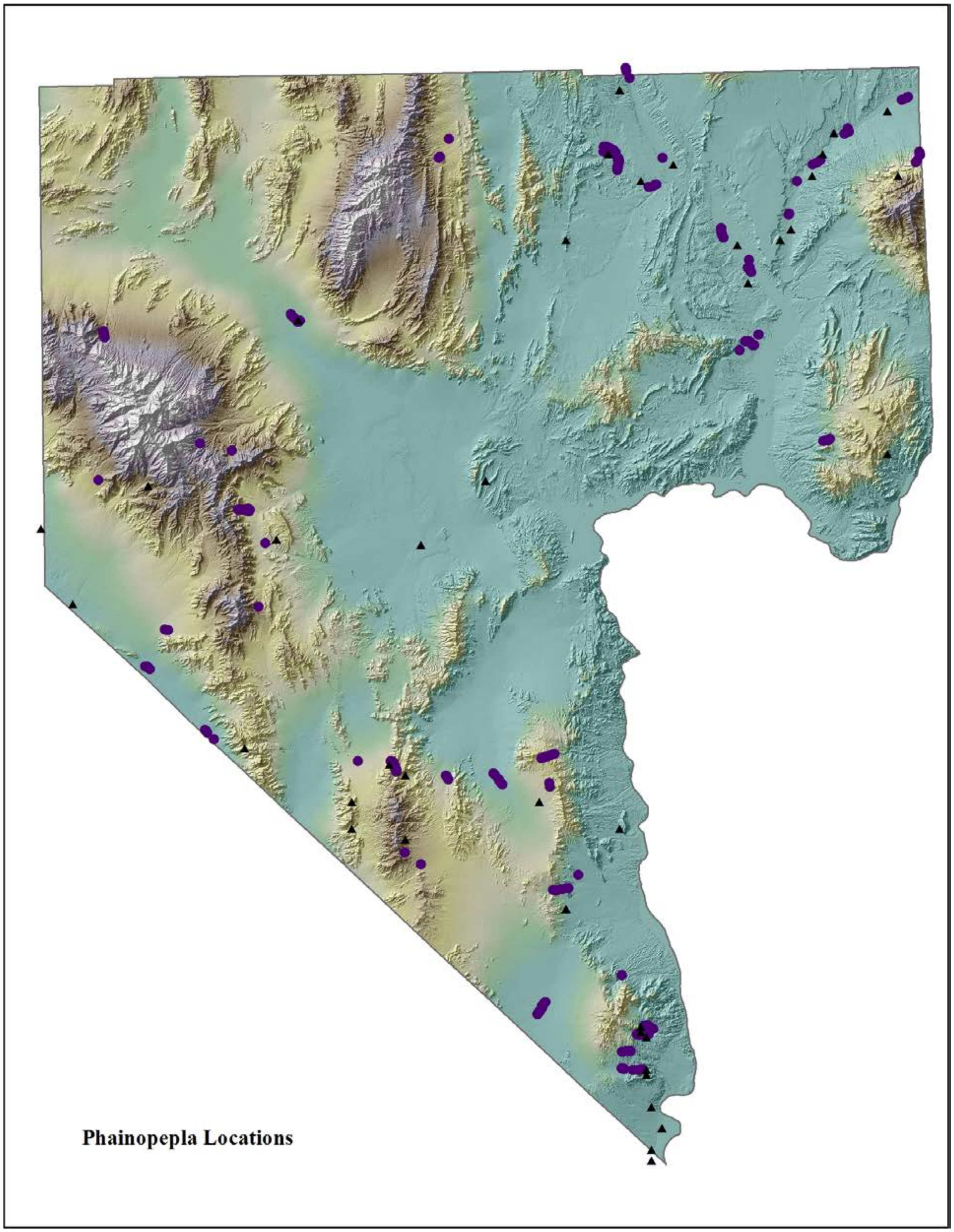

Figure 15. Phainopepla locations within Clark County. Circles indicate records at Nevada Bird Count transect points (2003-2013); triangles indicate Breeding Bird Atlas records (1998-2000).

Spatial Habitat Models

As the observed distribution and habitat use suggested, Phainopeplas are predicted to occur in most lower elevation, non-urban areas of Clark County (Figure 16). However, our findings on estimated densities suggest that the species really only thrives in near-riparian or riparian, mistletoe infested stands of mesquite, acacia, and cottonwood. Therefore, we caution that the species likely only regularly breeds in locations with such habitat types present, despite the fact that occasional individual are recorded outside of these habitat types.

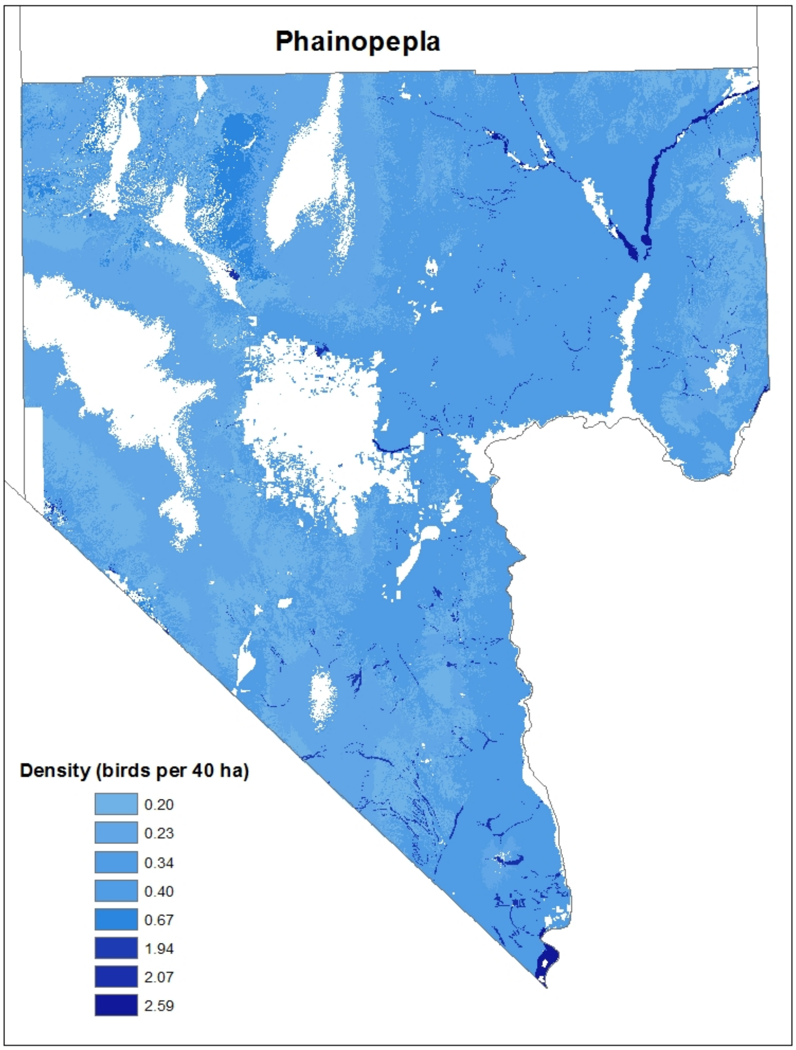

Figure 16. Predicted distribution of Phainopepla in Clark County. Mapped values represent the predicted density of Phainopepla in each GIS habitat category from the Clark County habitat map (Heaton et al. 2011).

The regional spatial data resulted in lower predicted densities for Phainopeplas across much of the Mojave landscape (Figure 17), most likely because the spatial data from LandFire take habitat condition classes into account that may reduce overestimation in unsuitable habitat types. As with other predictive models, we emphasize that local habitat types and conditions be evaluated at specific project locations in order to obtain a more definitive prediction of the presence and abundance of this species.

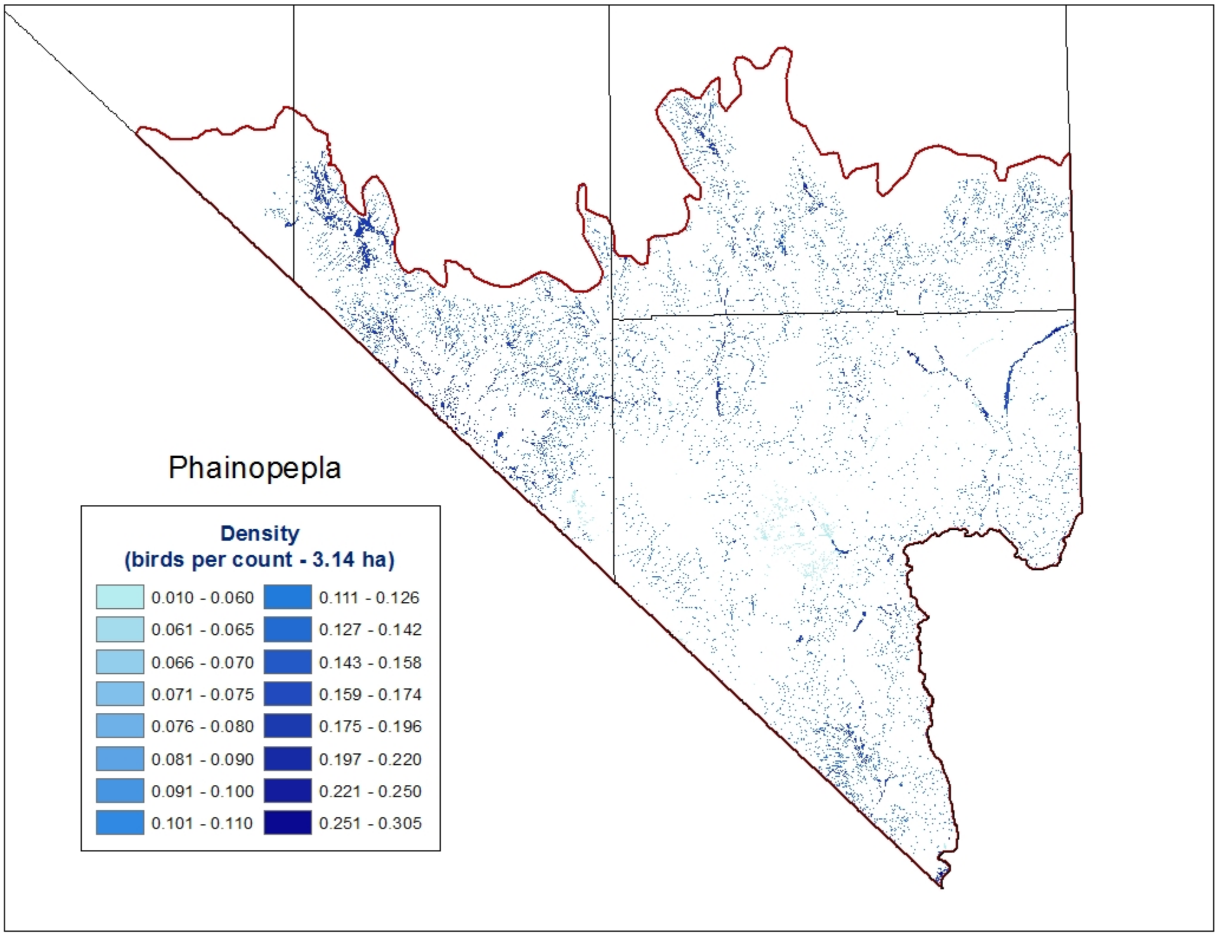

Figure 17. Predicted distribution of Phainopepla in Clark County and the surrounding Mojave Desert region of Nevada. Mapped values are derived from the mean abundance per point count in habitat categories according to Provencher and Anderson (2011).

Summer Tanager (Covered Species)

Photo and Rights: Martin Meyers

Conceptual Model

The Summer Tanager is mostly restricted to riparian gallery forests of the Southwest. It is a migratory bird, and as such, spends only its spring and summer breeding season in Nevada. It is restricted to the Mojave region in Nevada and occurs almost exclusively in riparian areas that feature a very tall woodland component, which may consist of cottonwood, Goodding's willow, or palm trees. With these requirements, it is particularly susceptible to ecological stressors that will diminish the coverage and vigor of riparian trees, and it is also likely fairly area sensitive in a sense that it requires large minimum habitat patches. Therefore, processes such as land conversion for agricultural and urban uses, decline in water deliveries, climate change, and other gradual loss of water-associated woodlands are of greatest concern to maintaining the species' populations in Clark County (Figure 18).

Summer Tanagers are uncommon or rare in Clark County, so their population may already fluctuate highly and may be fragmented to the point where mate availability may be a concern. Of the remaining breeding population, breeding success and success in locating food resources are likely the main processes that drive the current status of the Clark County population.

Ecological Stressors → **Important Habitat Effects** → **Expected Summer Tanager Responses**

Ecological Stressors

Structural Change

- Habitat conversion: urbanization, energy development, transportation corridors, catastrophic fires
- River channelization, impoundment, floodplain conversion to agriculture
- Recreational facilities

Change in Processes

- Introduced weeds
- Climate change
- Drought
- Change in fire regime
- Plant pathogens
- Change in river flow regimes

Important Habitat Effects

Habitat Loss

- Fragmentation and loss of riparian woodlands
- Loss of riparian shrub cover
- Loss of floodplain wetlands

Habitat Degradation

- Water stress/mortality in canopy trees
- Reduced riparian tree recruitment
- Decreased tree age class diversity
- Loss of native shrub and wetland covers
- Decreased water availability in soils and floodplain wetlands
- Decreased wetland invertebrate populations

Expected Summer Tanager Responses

Nesting

- Loss of suitable nest sites
- Increased territory sizes
- Increased nest failure rate
- Decreased reproductive output

Survival

- Longer travel for foraging
- Reduced foraging success
- Increased unpredictability of prey
- Stress response to loss of water and thermal shelters

Population

- Reduced recruitment of young
- Reduced site fidelity
- Decreased population size
- Fragmented population
- Increased population fluctuations

Recommendations for the Development of Indicators of Summer Tanager Population Effects: Baseline data on territory sizes, locations, nests (and nest success, if possible) in randomly selected occupied sites in Clark County. Research on prey use and availability to develop a simple indicator prey species monitoring plan. Long-term population monitoring of Summer Tanagers.

Figure 18. Summer Tanager conceptual habitat model, Clark County.

Density and Population Estimates

Summer Tanagers were primarily found in the lowland riparian stratum, though there was one record on a pinyon-juniper transect prior to 2008. Throughout their range, Summer Tanagers are almost exclusively found in tall riparian woodlands at low elevations, including tree-dominated cottonwood and willow woodlands and, at slightly higher elevations, they occasionally use mesquite and tamarisk (Robinson 2012).

We recorded 0.21 detections of Summer Tanagers per 40 ha within the lowland riparian stratum, and density estimates from removal models are almost identical to the raw detection data (Table 15). The estimated density using double sampling was higher with 0.73 birds/40 ha; however, the confidence intervals overlapped.

These density estimates are much lower than those reported elsewhere in the region. At the Bill Williams River delta to the lower Colorado River, Summer Tanager densities in cottonwood-willow reportedly ranged from 6 to 24 birds/40 ha (Robinson 2012). Along the San Pedro River, the highest numbers of Summer Tanagers were reported for cottonwood habitats (16.9 birds/40 ha), followed by mesquite and tamarisk (9.7 and 8.4 birds/40 ha, respectively; Brand et al. 2010), while in an earlier study, Krueper et al. (2003) reported overall Summer Tanager densities from 6 to 17 birds/40 ha. In central Arizona, Szaro and Jakle (1985) reported similarly high densities of 5.0 to 15.9 birds/40 ha. These comparisons with other studies from the region agree with the notion that Summer Tanagers are relatively rare in Clark County, which is also at the periphery of their range.

Overall, we estimated 38 individuals to be within Clark County using removal analyses, or 130 individuals using the double-sampling; however, the confidence intervals overlapped. There were also large differences in the annual point estimates, using the double-sampling estimates; however, the confidence intervals all overlapped and included zero.

Table 15. Estimated density and population size of Summer Tanagers in Clark County by year and habitat stratum, 2008-2013.

Stratum	2008	2009	2010	2011	2012	2013	2012-2013	Overall (2003-2013)
Lowland Riparian								
Raw density of detections	0.60 (0, 1.79)		0.12 (0, 0.35)		0.12 (0, 0.35)	0.44 (0, 1.20)	0.29 (0, 0.74)	0.21 (0, 0.52)
Density Estimates (Double-Sampling)	2.04 (0, 6.13)		0.40 (0, 1.21)		0.40 (0, 1.21)	1.49 (0, 4.09)	0.98 (0, 2.53)	0.73 (0, 1.77)
Density Estimates (Removal)	N/A		N/A		N/A	N/A	N/A	0.21 (0.17, 0.50)
Raw population size estimate	107.0 (0, 321.0)		21.1 (0, 63.4)		21.1 (0, 63.4)	78.0 (0, 214.5)	51.3 (0, 132.8)	38.0 (0, 93.0)
Population Size (Double-sampling)	365.8 (0, 1097.7)		72.3 (0, 217.0)		72.3 (0, 217.0)	266.8 (0, 733.6)	175.5 (0, 454.2)	130.1 (0, 318.1)
Population Size (Removal Modeling)	N/A		N/A		N/A	N/A	N/A	38.1 (30.2, 90.2)
Pinyon-Juniper								
Raw density of detections								0.01 (0, 0.02)
Density Estimates (Double-Sampling)								0.03 (0, 0.08)
Raw population size estimate								23.0 (0, 69.1)
Population Size (Double-sampling)								78.6 (0, 236.4)
Total								
Population Size (Double-sampling) / (Removal)	365.8		72.3		72.3	266.8	175.5	208.7 / 38.1

Habitat Use

The Summer Tanager is one of only few Clark County landbirds that occurs almost exclusively in large and intact stands of mature riparian gallery forests (Figure 19). It requires open stands of old cottonwood or willow trees that have reached their maximum height, interspersed with riparian shrub thickets, wetlands, or wet meadows. Summer Tanagers generally avoid heavily degraded riparian areas, where significant loss of understory cover or conversion to agriculture has occurred in stands that would otherwise be suitable for Summer Tanager nesting. The species nests – and forages – in the canopy of old riparian trees, which is partially the reason little is known about their nesting biology in the Southwest. The species is also fairly rare in Nevada, likely due to the low availability of their preferred habitat type. Because of its requirement of large stands of fairly intact, mature riparian forests, the species itself makes for a good indicator of riparian habitat integrity.

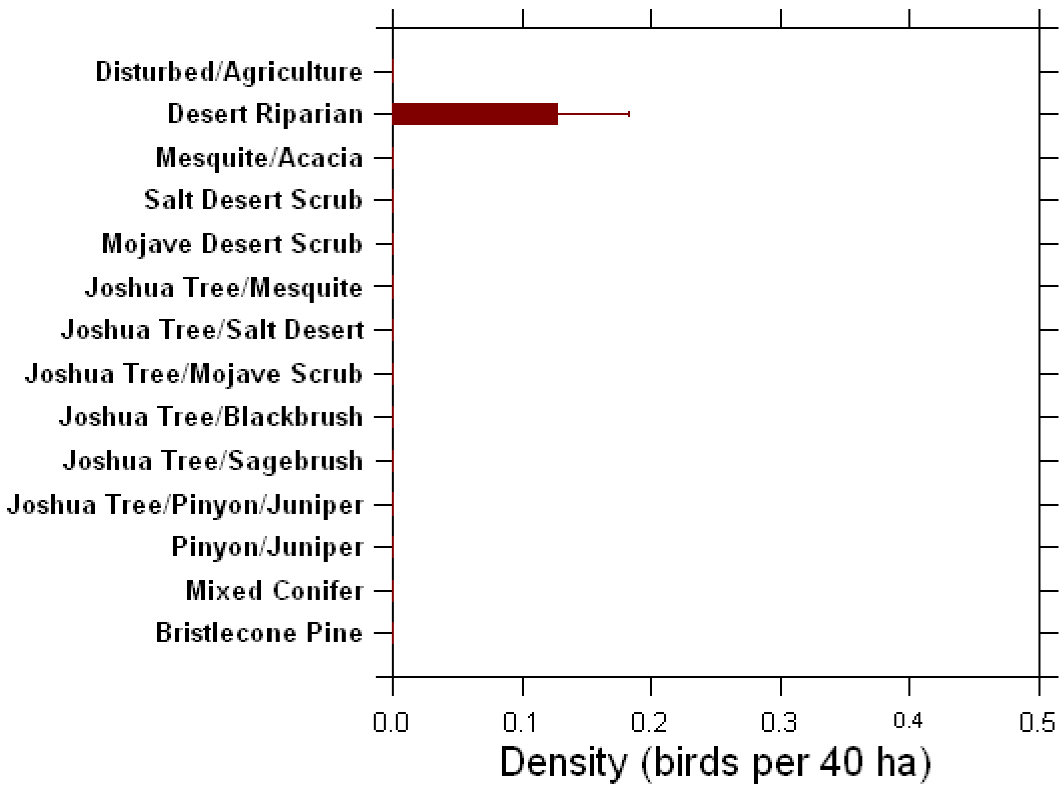

Figure 19. Estimated density (mean and standard error) of the Summer Tanager at points in Clark County dominated by each GIS habitat grouping, from the Clark County habitat map (Heaton et al. 2011).

Statistical Habitat Model

We found that estimated densities for Summer Tanager were significantly higher in plots where the following habitat features were present compared with plots where they were absent: surface water within 100 m and 1000 m, or deciduous trees and riparian shrubs within the plot (Table 16). Based on dominant plants that were present on plots, their estimated densities were higher in places that had cottonwood, tamarisk, or mesquite present. Compared to other focal species, sample sizes were low for Summer Tanager due to their rarity in Clark County. Therefore, some habitat selection patterns might not be revealed in our study.

Table 16. Comparison of estimated densities (birds per 40 ha) for Summer Tanager, with and without selected habitat or landscape elements, along with p-values from the ANOVA tests.

	Absent	Present	ANOVA p-value
Roads within 400 m	0.00	0.03	0.06
Development 1000 m	0.01	0.05	0.16
Water within 100 m	0.01	0.08	0.02
Water within 1000 m	0.00	0.10	0.00
Dry Wash within 100 m	0.05	0.00	0.00
Trees within 100 m	0.03	0.01	0.35
Deciduous trees	0.01	0.07	0.05
Coniferous trees	0.02	0.00	0.32
Trees within 1000 m	0.00	0.02	0.26
Riparian Shrub within 100 m	0.00	0.12	0.00
Grazing within 100 m	0.02	0.00	0.41
Tall cholla within 100 m	0.02	0.00	0.30
Mistletoe within 100 m	0.01	0.02	0.65
From plant species lists (all within 100 m):			
Joshua Tree	0.02	0.00	0.21
Mojave Yucca	0.02	0.00	0.22
Acacia	0.02	0.00	0.25
Mesquite	0.00	0.16	0.00
Pinyon Pine	0.02	0.00	0.40
Juniper	0.02	0.00	0.36
Willow	0.02	0.00	0.74
Tamarisk	0.01	0.13	0.00
Creosote	0.04	0.00	0.02
Saltbush	0.01	0.03	0.32
Cliffrose	0.02	0.00	0.52
Sagebrush	0.02	0.00	0.42
Cottonwood	0.01	0.26	0.00

The Summer Tanager is common in the southeastern United States, so much of the literature is not relevant to the extreme western edge of their range that includes Nevada. Western populations occupy riparian woodlands dominated by willow and cottonwood trees (Robinson 2012), or sycamores (Powell and Steidl 2002). In one restoration project on the San Pedro River in Arizona, Summer Tanager densities increased three-fold within four years of cattle removal (Krueper et al. 2003). In another study at the San Pedro River, densities were at least twice as high in cottonwood compared with mesquite or tamarisk, and no tanager nests were found in tamarisk shrubs (Brand et al. 2010). Patch size can also be important, and Summer Tanager abundance was correlated with the size of the nearest cottonwood-willow patch, and with the density of cottonwood and willow trees in the nearest patch, at the lower Colorado River (Lynn 1996).

Observed Actual Distribution

As a riparian-obligate species, Summer Tanager was almost exclusively recorded in spring and stream systems of Clark County that feature tall riparian trees (Figure 20). Interestingly, we see repeated records from the springs of the Red Rock area in the foothills of the Spring Mountains, where other riparian focal species of this study have not been reported. Other sites with records include Corn Creek in the Desert Wildlife Range, Meadow Valley Wash, and the upper Muddy River. Therefore, Summer Tanagers appear to focus their habitat selection primarily on the presence of appropriate breeding habitat, rather than patch size or size of stream.

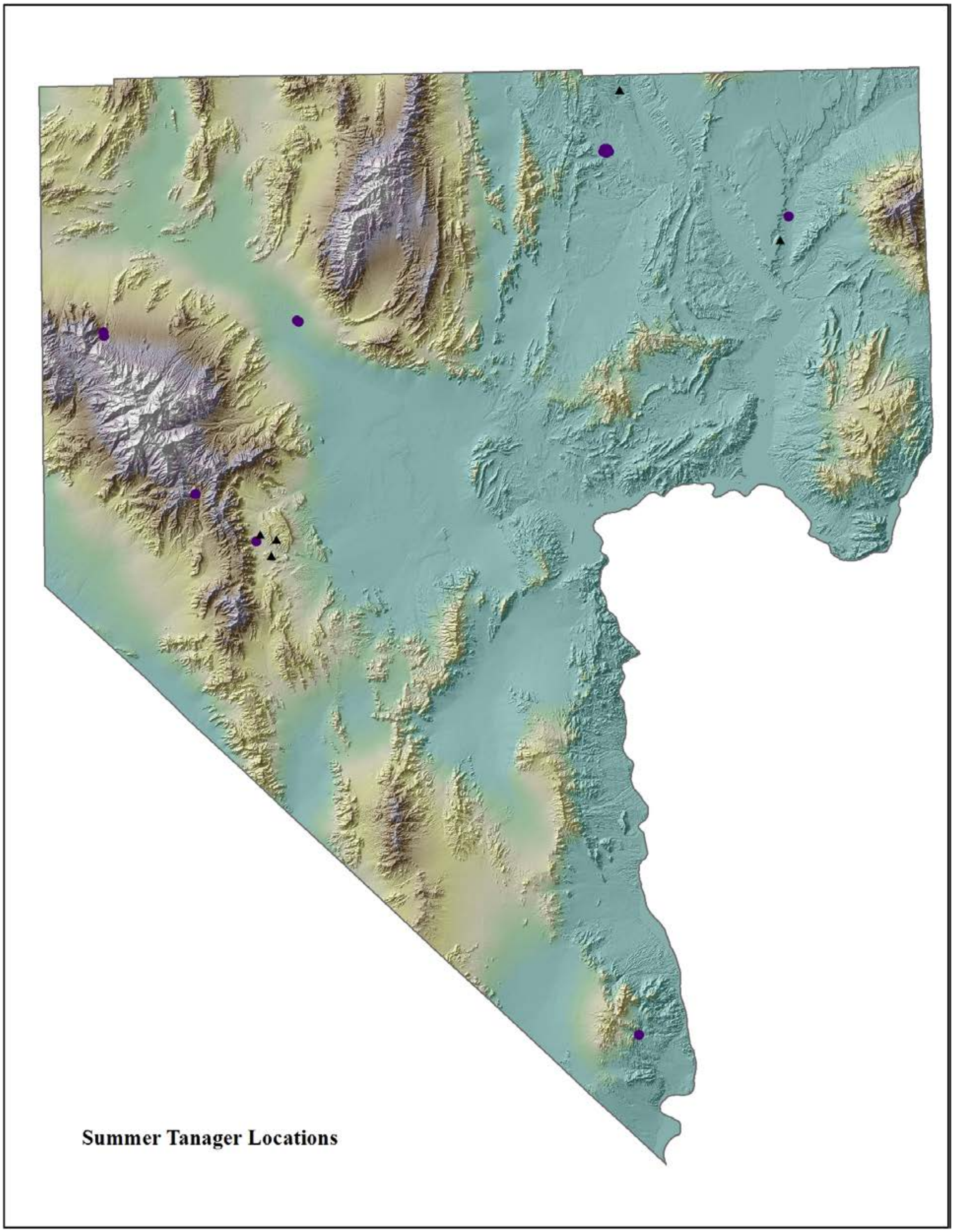

Figure 20. Summer Tanager locations within Clark County. Circles indicate records at Nevada Bird Count transect points (2003-2013); triangles indicate Breeding Bird Atlas records (1998-2000).

Spatial Habitat Models

In our predictive model of where Summer Tanagers are estimated to occur in Clark County (Figure 21), we observe the same hotspots as for the other riparian-specialized focal species, such as Bell's Vireo and Blue Grosbeak. However, these predictions should probably be viewed as potential areas where the species would be, if there were appropriate riparian woodlands. In our experience, much of the lower Muddy and Virgin rivers lack tall gallery forests, so we might interpret the map as areas of *potential* Summer Tanager habitat, if their preferred habitat features can be restored. We also emphasize that restoration and enhancement of small spring systems, such as seen in the example of Corn Creek, would likely be very beneficial to this species, as its current distribution includes such sites with surprising regularity.

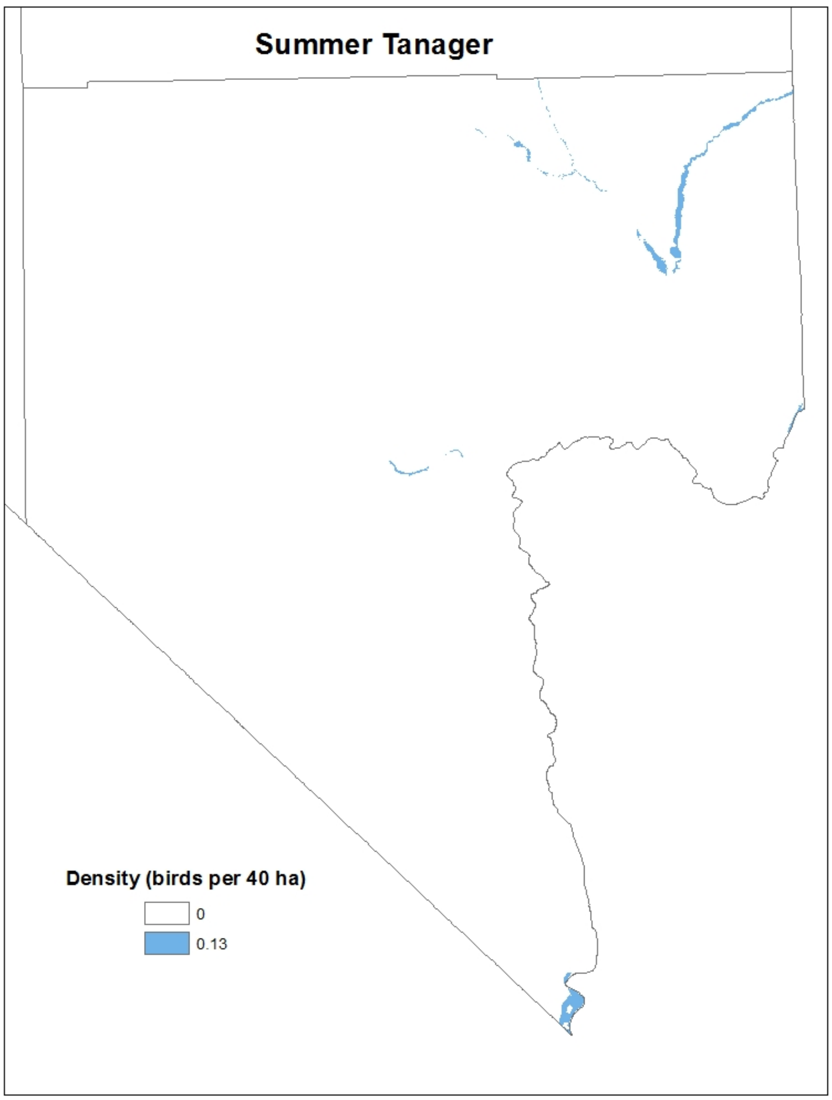

Figure 21. Predicted distribution of Summer Tanager in Clark County. Mapped values represent the predicted density of the Summer Tanager in each GIS habitat category from the Clark County habitat map (Heaton et al. 2011).

Vermilion Flycatcher (Covered Species)

Photo and Rights: Jennifer Ballard

Conceptual Model

Vermilion Flycatcher remains perhaps the most mysterious of the nine focal species, which is partly due to its relative rarity as a breeder in Clark County and throughout the lower Colorado River system. It is a riparian-associated species that also breeds in “riparian surrogate” habitats, such as irrigated agricultural lands, city parks, cemeteries, and other irrigated lands. Therefore, ecological stressors on their habitat and their populations are comparatively difficult to define (Figure 22), and we used the same conceptual model as we used for other riparian-associated focal species, simply because we concluded that the historic habitat association of Vermilion Flycatcher was that of a riparian-obligate. The one semi-natural breeding site of the species, where we also observed the highest breeding territory density in Clark County, was on the Warm Springs Natural Area in the upper Muddy River, which we use as a reference site for the species' habitat needs. Unlike the other riparian focal species, Vermilion Flycatcher selects open park-like stands of mesquite and other riparian deciduous trees. The open canopy undoubtedly aids in their preferred foraging method, which is sallying from tall perches for insects in woodland openings. However, most naturally park-like stands of riparian trees in the Mojave Desert are interspersed with heavily degraded and dry ground cover, and Vermilion Flycatcher appears to require a fairly intact, wet, or even saturated herbaceous layer between trees that likely produces the insects on which it forages. Apparently the species can readily use alternate, artificially created habitats that simulate these conditions, such as city parks and agricultural areas. However, maintenance of their populations may require that such suitable sites be actively restored or enhanced, as this species is rare and has very disjunct populations in Clark County.

Ecological Stressors → **Important Habitat Effects** → **Exp. Vermilion Flycatcher Responses**

Ecological Stressors

Structural Change

- Habitat conversion: urbanization, industrial/energy development, transportation corridors, catastrophic fires
- River channelization, impoundment, floodplain conversion to agriculture
- Recreational facilities

Change in Processes

- Introduced weeds
- Climate change
- Drought
- Change in fire regime
- Ungulate grazing
- Change in river flow regimes and groundwater tables

Important Habitat Effects

Habitat Loss

- Loss of riparian galley forest
- Loss of riparian shrub cover
- Loss of floodplain wetlands and wet meadows

Habitat Degradation

- Water stress/mortality, or defoliation of shrubs
- Reduced riparian shrub recruitment
- Loss of native shrub and wetland covers
- Decreased water availability in soils and floodplain wetlands
- Decreased wetland invertebrate populations

Exp. Vermilion Flycatcher Responses

Nesting

- Loss of suitable nest sites
- Increased territory sizes
- Increased nest failure rate
- Decreased reproductive output

Survival

- Longer travel for foraging
- Reduced foraging success
- Increased unpredictability of prey
- Stress response to loss of water and thermal shelters

Population

- Reduced recruitment of young
- Reduced site fidelity
- Decreased population size
- Fragmented population
- Increased population fluctuations

Recommendations for the Development of Indicators of Vermilion Flycatcher Population Effects: Baseline data on territory sizes, locations, nests (and nest success, if possible) in randomly selected occupied sites in Clark County. Research on prey use and availability to develop a simple indicator prey species monitoring plan. Long-term population monitoring of Vermilion Flycatchers.

Figure 22. Vermilion Flycatcher conceptual habitat model, Clark County.

Density and Population Estimates

Vermilion Flycatchers mostly breed within cottonwood-dominated and mesquite-dominated riparian woodlands, and mesquite bosques (Ellison et al. 2009). In Clark County, they were found in higher densities in the agricultural stratum than in the lowland riparian stratum. We recorded 0.86 detections/40 ha in the agricultural stratum (Table 17), which was lower than estimates from both the removal and double-sampling methods. However, the confidence intervals of all of these overlapped. We recorded 0.26 detections/40 ha within lowland riparian, which was similar to the corrected estimate from removal modeling, but less than that estimated using double-sampling. The confidence intervals also overlapped between strata.

The Clark County density estimates are much lower than those reported elsewhere in the region. Along the San Pedro River in Arizona, densities of 20.8 birds/40 ha were reported for cottonwood habitats, distantly followed by tamarisk, grassland, and mesquite (9.56, 9.28, and 7.12 birds/40 ha, respectively; Brand et al. 2010), and Krueper et al. (2003) reported densities of 3.76 to 11.7 birds/40 ha in earlier surveys of the same area.

Annual estimates of the population size of Vermilion Flycatcher were relatively similar among years within strata, except for lowland riparian in 2012. However, all of the confidence intervals overlapped and included zero. Detections were very localized and, of our random transects, most of the detections in lowland riparian were on one transect at Warm Springs Natural Area. The removal population estimate within the agricultural stratum was intermediate between that from the raw data and double-sampling, and all had overlapping confidence intervals. The lowland riparian estimates differed, with the removal estimate more closely approximating the raw estimate, though the confidence intervals overlapped. In both strata, the confidence intervals for the removal estimates were narrower than those for the double-sampling.

Table 17. Estimated density and population size of Vermilion Flycatchers in Clark County by year and habitat stratum, 2008-2013.

Stratum	2008	2009	2010	2011	2012	2013	2012-2013	Overall (2003-2013)
Agriculture								
Raw density of detections	1.27 (0, 2.55)	1.91 (0, 3.82)	1.91 (0, 3.82)	1.91 (0, 3.82)		0.91 (0, 1.82)	0.61 (0, 1.21)	0.86 (0.07, 1.68)
Density Estimates (Double-Sampling)	4.35 (0, 8.71)	6.53 (0, 13.06)	6.53 (0, 13.06)	6.53 (0, 13.06)		3.11 (0, 6.22)	2.07 (0, 4.15)	2.94 (0.24, 5.75)
Density Estimates (Removal)	N/A	N/A	N/A	N/A		N/A	N/A	1.65 (1.31, 3.76)
Raw population size estimate	86.1 (0, 172.3)	129.2 (0, 258.5)	129.2 (0, 258.5)	129.2 (0, 258.5)		61.5 (0, 123.1)	41.0 (0, 82.1)	58.1 (4.7, 113.7)
Population Size (Double-sampling)	294.6 (0, 589.4)	441.9 (0, 883.9)	441.9 (0, 883.9)	441.9 (0, 883.9)		210.5 (0, 420.9)	140.3 (0, 280.7)	198.7 (16.2, 389.0)
Population Size (Removal Modeling)	N/A	N/A	N/A	N/A		N/	N/A	111.7 (88.7, 254.6)
Lowland Riparian								
Raw density of detections		0.17 (0, 0.51)	0.33 (0, 0.98)	0.17 (0, 0.51)	1.44 (0, 4.03)	0.42 (0, 1.08)	0.75 (0, 1.99)	0.26 (0.01, 0.60)
Density Estimates (Double-Sampling)		0.58 (0, 1.75)	1.12 (0, 3.37)	0.58 (0, 1.75)	4.92 (0, 13.79)	1.45 (0, 3.68)	2.56 (0, 6.81)	0.90 (0.03, 2.05)
Density Estimates (Removal)		N/A	N/A	N/A	N/A	N/A	N/A	0.35 (0.26, 1.02)
Raw population size estimate		30.6 (0, 91.8)	58.9 (0, 176.5)	30.6 (0, 91.8)	257.8 (0, 722.6)	76.1 (0, 193.0)	134.0 (0, 356.8)	47.3 (1.4, 107.3)
Population Size (Double-sampling)		104.5 (0, 313.8)	201.3 (0, 603.7)	104.5 (0, 313.8)	881.6 (0, 2471.2)	260.1 (0, 660.1)	458.3 (0, 1220.3)	161.9 (4.9, 367.1)
Population Size (Removal Modeling)		N/A	N/A	N/A	N/A	N/	N/A	62.6 (47.4, 183.3)
Total								
Population Size (Double-sampling) / (Removal)	294.6	546.5	643.2	546.5	881.6	470.6	598.6	360.6 / 174.2

Habitat Use

Vermilion Flycatcher is perhaps the only focal species of this project that tolerates heavily landscaped riparian habitats (despite the presumption that it historically occurred only in intact riparian settings). It is found nesting in open park-like stands of riparian mesquite, cottonwood, and willow, but also in quasi-riparian settings such as city parks, cemeteries, and low-impact agriculture (Figure 23). As a flycatcher, the species forages almost exclusively on flying insects, which are produced in nearby wetlands, wet meadows, and riparian woodlands. The park-like setting that they appear to prefer facilitates their foraging mode of hawking insects. Much has yet to be learned about the territory site selection, site fidelity, and ecology of this species. Preservation of currently occupied sites is therefore perhaps the most immediate conservation strategy until more information is gained on the species' conservation needs.

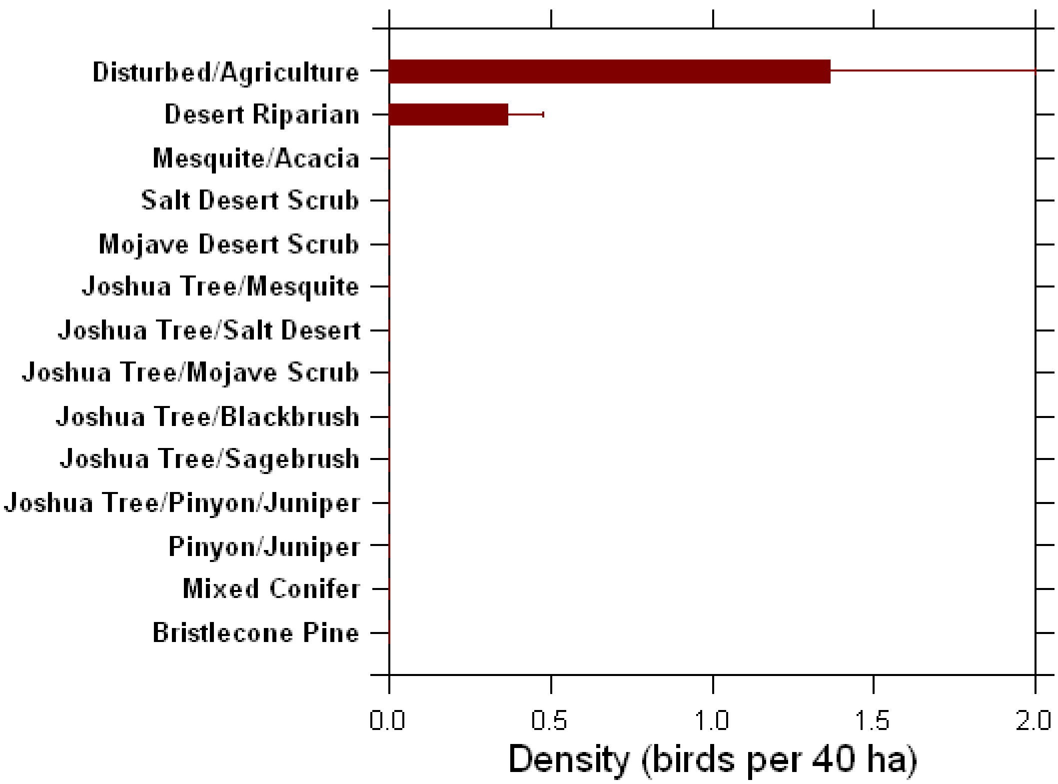

Figure 23. Estimated density (mean and standard error) of the Vermilion Flycatcher at survey points in Clark County dominated by each GIS habitat grouping, from the Clark County habitat map (Heaton et al. 2011).

Statistical Habitat Model

We found that estimated densities of Vermilion Flycatcher were significantly higher on plots where the following habitat features were present compared with plots where they were absent: roads within 400 m, developments within 1000 m, surface water within 100 and 1000 m, deciduous trees and riparian shrubs within the plot; their estimated densities were significantly lower on plots with a dry wash than on plots without one (Table 18). Vermilion Flycatcher habitat selection based on dominant plant types features higher densities in plots where mesquite, tamarisk, or cottonwood were present than in plots where these were absent.

As with other riparian focal species, nearby roads and developments do not appear to deter Vermilion Flycatchers from using a site for the breeding season. This is likely a result that most, or all, riparian areas and springs have roads or developments nearby, and few if any exist in remote areas of Clark County. However, as discussed earlier, Vermilion Flycatcher is also one of the very few native riparian species that readily accepts heavily modified and surrogate habitats. These results are similar to those found elsewhere in the region, where they are typically found near water, in open riparian woodlands, with cottonwood, willow and mesquite (Ellison et al. 2009).

Table 18. Comparison of estimated densities (birds per 40 ha) for Vermilion Flycatcher, with and without selected habitat or landscape elements, along with p-values from the ANOVA tests.

	Absent	Present	ANOVA p-value
Roads within 400 m	0.00	0.07	0.02
Development 1000 m	0.00	0.20	0.00
Water within 100 m	0.00	0.36	0.00
Water within 1000 m	0.00	0.20	0.00
Dry Wash within 100 m	0.11	0.00	0.00
Trees within 100 m	0.01	0.05	0.21
Deciduous trees	0.00	0.29	0.00
Coniferous trees	0.04	0.00	0.23
Trees within 1000 m	0.00	0.05	0.17
Riparian Shrub within 100 m	0.00	0.24	0.00
Grazing within 100 m	0.04	0.01	0.52
Tall cholla within 100 m	0.04	0.00	0.21
Mistletoe within 100 m	0.03	0.06	0.32
From plant species lists (all within 100 m):			
Joshua Tree	0.05	0.00	0.13
Mojave Yucca	0.05	0.00	0.13
Acacia	0.05	0.00	0.16
Mesquite	0.02	0.18	0.00
Pinyon Pine	0.04	0.00	0.30
Juniper	0.04	0.00	0.27
Willow	0.02	0.33	0.00
Tamarisk	0.01	0.24	0.00
Creosote	0.08	0.00	0.01

	Absent	Present	ANOVA p-value
Saltbush	0.04	0.00	0.27
Cliffrose	0.04	0.00	0.43
Sagebrush	0.04	0.00	0.32
Cottonwood	0.01	1.17	0.00

Observed Actual Distribution

Vermilion Flycatcher was observed in only a handful of locations in Clark County, such as the upper and lower Muddy River and the Virgin River (Figure 24). In comparison with the other riparian focal species, it is curious that this species apparently makes little or no use of small spring systems in Clark County, which is likely a result of it requiring a fairly large minimum habitat patch for setting up a territory, or perhaps avoidance of areas that can only support one territory. Thus, we suspect that behavioral factors may be involved in the typical clustering of multiple nearby Vermilion Flycatcher breeding territories that we have observed in most known breeding sites of the species.

Due to the very low sample size of Vermilion Flycatcher records in Clark County, we were not able to project their distribution in the form of predictive spatial models.

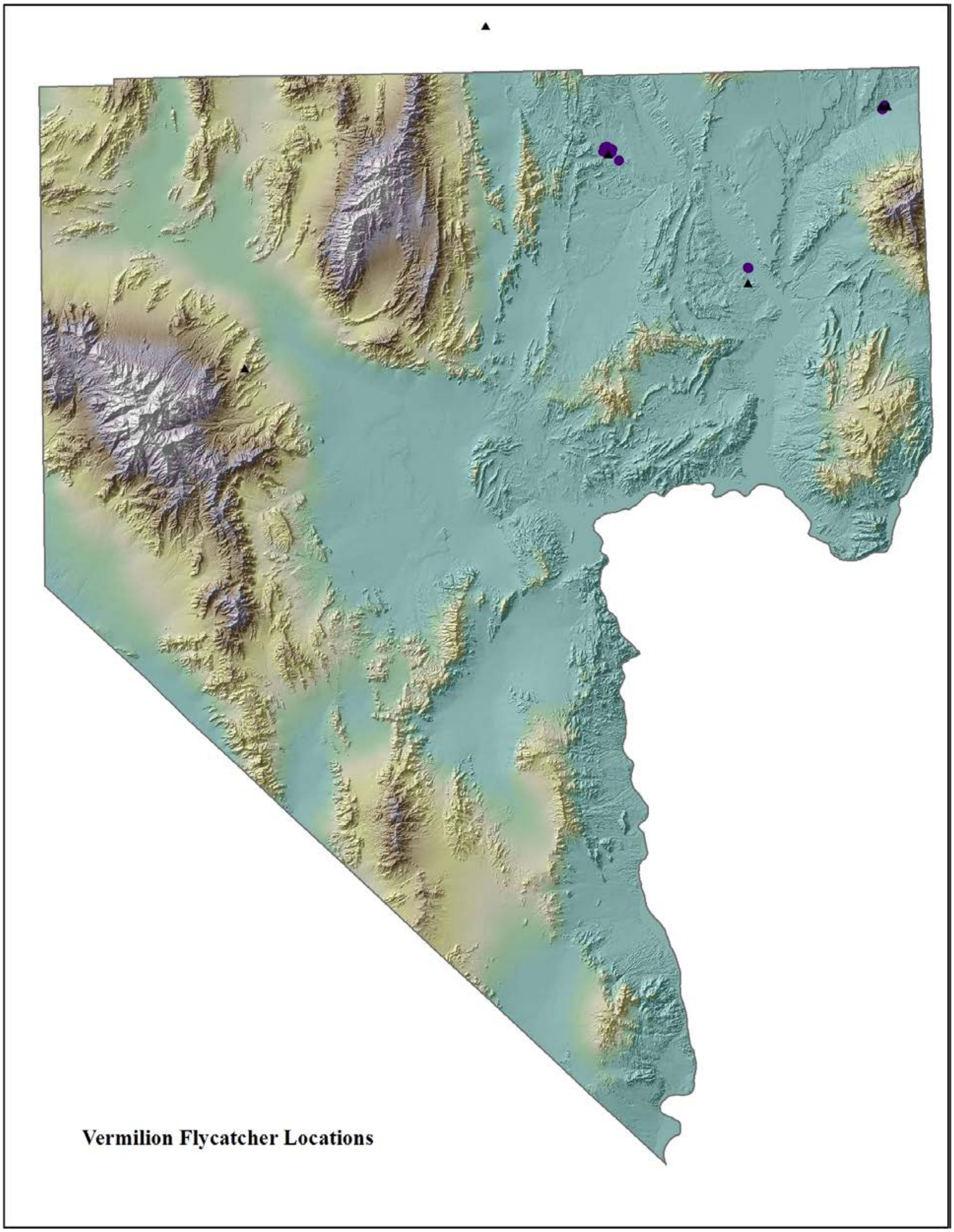

Figure 24. Vermilion Flycatcher locations within Clark County. Circles indicate records at Nevada Bird Count transect points (2003-2013); triangles indicate Breeding Bird Atlas records (1998-2000).

Willow Flycatcher (Covered Species)

Photo and Rights: Martin Meyers

Conceptual Model

The Willow Flycatcher's subspecies *extimus*, which is federally listed as endangered, breeds in Clark County's remaining intact riparian areas. While our project did not directly address which of the Willow Flycatchers recorded were nesting, we assume that our records mostly reflect breeding populations, or at least potential breeding sites for the species. With this in mind, most areas in which the species occurs in Clark County are strictly riparian, as the species is especially intolerant of other habitat types. As a result, all ecological stressors that affect riparian areas are important threats to maintaining Willow Flycatcher populations in Clark County, namely, loss of riparian shrub coverage to a variety of land uses, dewatering of stream systems and floodplains, climate change, and other causes of riparian woodland degradation (Figure 25). The most recent stressor that was added to this list is the invasion of the tamarisk beetle (*Diorhabda carinulata*), which arrived in Clark County in 2011 and began to radically defoliate tamarisk in the major tributaries to the lower Colorado River. Its effects on breeding Willow Flycatchers were first observed in southern Utah, where nests built in tamarisk were exposed to the sun and largely failed. Because the species' primary nesting habitat, shrub willows, has been replaced with tamarisk in most rivers and streams of the Southwest over past decades, the species now makes significant use of tamarisk as a nesting substrate. Therefore, the tamarisk beetle presents perhaps the most immediate current threat to the remaining breeding populations in Clark County.

Ecological Stressors → **Important Habitat Effects** → **Expected Willow Flycatcher Responses**

Ecological Stressors

Structural Change

- Habitat conversion: urbanization, energy development, transportation corridors, catastrophic fires
- River channelization, impoundment, floodplain conversion to agriculture
- Recreational facilities

Change in Processes

- Introduced weeds
- Climate change
- Drought
- Change in fire regime
- Ungulate grazing
- Salt cedar beetle
- Change in river flow regimes and groundwater tables

Important Habitat Effects

Habitat Loss

- Fragmentation and loss of riparian woodlands
- Loss of riparian shrub cover
- Loss of floodplain wetlands

Habitat Degradation

- Water stress/mortality, or defoliation of shrubs
- Reduced riparian shrub recruitment
- Loss of native shrub and wetland covers
- Decreased water availability in soils and floodplain wetlands
- Decreased wetland invertebrate populations

Expected Willow Flycatcher Responses

Nesting

- Loss of suitable nest sites
- Increased territory sizes
- Increased nest failure rate
- Decreased reproductive output

Survival

- Longer travel for foraging
- Reduced foraging success
- Increased unpredictability of prey
- Stress response to loss of water and thermal shelters

Population

- Reduced recruitment of young
- Reduced site fidelity
- Decreased population size
- Fragmented population
- Increased population fluctuations

Recommendations for the Development of Indicators of Willow Flycatcher Population Effects:
Research on prey use and availability to develop a simple indicator prey species monitoring plan.
Long-term population monitoring of Phainopeplas.

Figure 25. Willow Flycatcher conceptual habitat model, Clark County.

Density and Population Estimates

Willow Flycatchers were recorded exclusively within the lowland riparian stratum, where we recorded 0.02 detections of Willow Flycatchers per 40 ha (Table 19), and the density estimate based on double-sampling estimate was 0.10 birds/40 ha. The sample size was insufficient for performing removal analyses. Overall, we estimated 18 birds within Clark County, though the confidence interval included zero. Based on annual abundances cited in McLeod and Pellegrini (2013), SWCA Environmental Consultants' intensive surveys of suitable habitat resulted in a Nevada-wide estimated populations size in the high 40s to high 60s between 2008 and 2012, and these estimates are well beyond the upper bound of our 95% confidence interval. This difference in estimates is likely due to the very spotty distribution of Willow Flycatchers in Clark County, which increases the chances that a random sampling plan misses parts of the small population.

Willow Flycatchers tend to cluster within suitable habitat, rather than spread evenly through available, possibly suitable habitat (USFWS 2002), and high breeding densities can be reached in some locations (Sedgwick 2000). Southwestern Willow Flycatchers prefer wet riparian areas with dense tree or shrub cover that is 2 - 5 m tall with a variable overstory layer, and it has also been reported to breed in tamarisk (Sedgwick 2000, Sogge et al. 2010). In the desert Southwest, Paxton et al. (2007) reported approximately 4.8 birds/40 ha in the riparian areas they sampled in central Arizona, compared to our 0.02 detections/40 ha in the lowland riparian stratum.

Table 19. Estimated density and population size of Willow Flycatchers in Clark County by year and habitat stratum, 2008-2013.

Stratum	2008	2009	2010	2011	2012	2013	2012-2013	Overall (2003-2013)
Lowland Riparian								
Raw density of detections		0.11 (0, 0.34)		0.11 (0, 0.34)				0.02 (0.00, 0.04)
Density Estimates (Double-Sampling)		0.65 (0, 1.95)		0.65 (0, 1.95)				0.10 (0, 0.22)
Raw population size estimate		20.4 (0, 61.1)		20.4 (0, 61.1)				3.1 (0, 7.0)
Population Size (Double-sampling)		116.9 (0, 350.8)		116.9 (0, 350.8)				17.6 (0, 40.1)
Total								
Population Size (Double-sampling)		116.9		116.9				17.6

Habitat Use

The sample sizes from this study were too low for conducting meaningful analyses on Willow Flycatcher habitat characteristics. Our records were in lowland riparian habitat, which is where almost all known breeding records of the species occur regionally. As an endangered subspecies, much research has already been done on habitat needs and conservation planning of the Southwestern Willow Flycatcher, to which we refer the reader instead of presenting data for our limited dataset. McLeod and Pellegrini (2013), in particular, provide a useful analysis of the demographic and habitat status of the Southwestern Willow Flycatcher within the region, and refer in detail to specific sites within Nevada and Clark County. In short, the species requires dense, fairly large riparian shrub thickets that grow in saturated wetland soils. Much evidence points to a preference for native riparian shrubs, particularly willows; however, they also nest in tamarisk especially if a native shrub component is present in their breeding territory, and productivity in these non-native stands can be similar or higher than that in nearby native stands (Sogge et al. 2010, Sogge et al. 2008, Finch and Stoleson 2000).

Observed Actual Distribution

Most Willow Flycatcher records we compiled from our surveys were from the Muddy and Virgin rivers in Clark County (Figure 26). Although occasional records were from smaller spring systems throughout the county, we believe that these were of transient individuals that were not using the sites as breeding habitat. The actual nesting distribution of Southwestern Willow Flycatcher is well-documented from intensive surveys that have occurred due to its federal status as endangered.

As with Vermilion Flycatcher, the sample sizes from our surveys for were too low for Willow Flycatcher to produce meaningful predicted distributions.

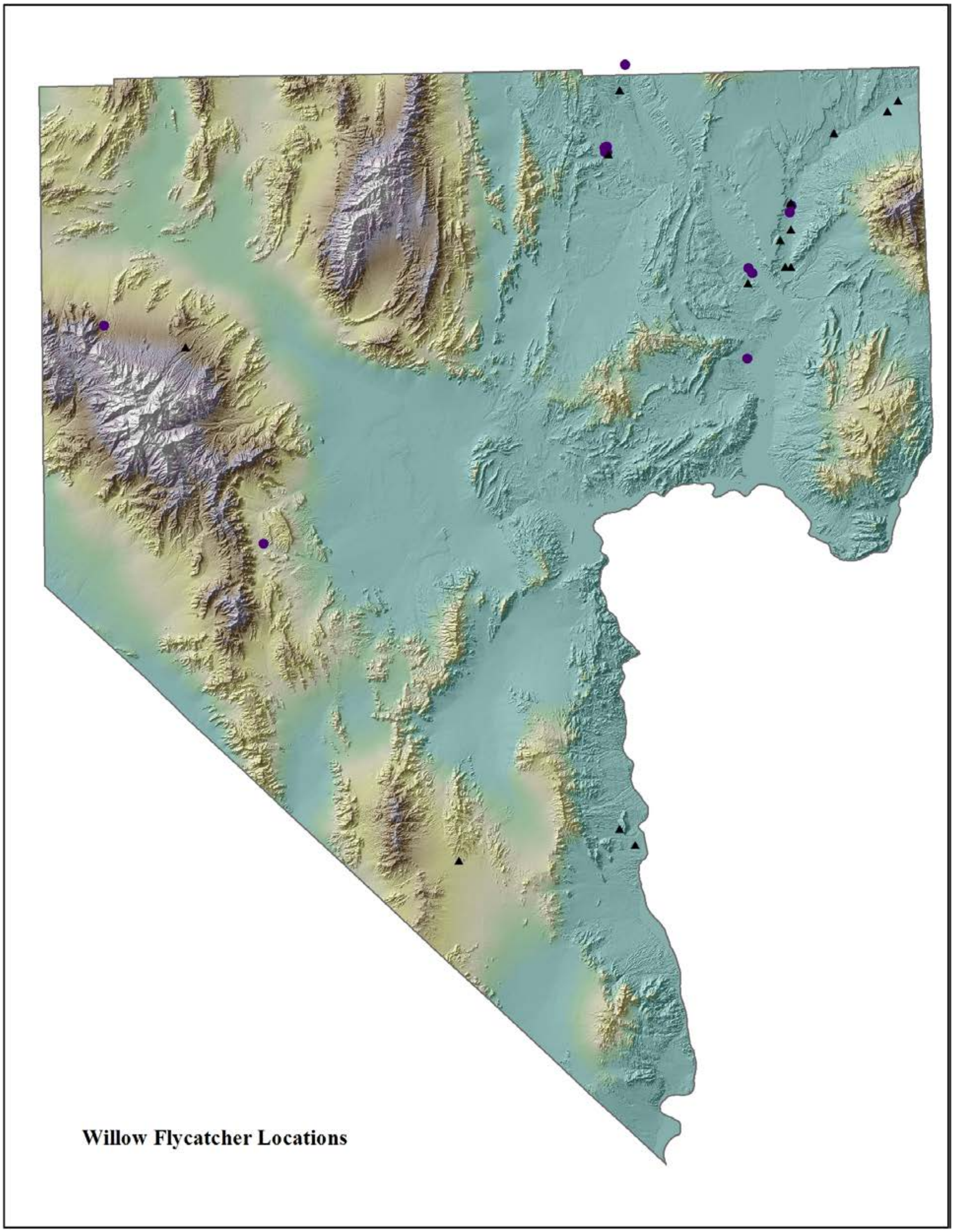

Figure 26. Willow Flycatcher locations within Clark County. Circles indicate records at Nevada Bird Count transect points (2003-2013); triangles indicate Breeding Bird Atlas records (1998-2000).

Bendire's Thrasher (Evaluation Species)

Photo and Rights: Martin Meyers

Conceptual Model

Bendire's Thrasher is, like the other two MSHCP evaluation species, restricted to desert upland habitats of Clark County. Unlike the MSHCP covered species in our report, it is therefore less affected by threats to riparian areas but deals with stressors that are typical for desert uplands (Figure 27). These may include habitat conversion for developments and infrastructure, motorized recreation, change in fire frequency, and climate change effects on precipitation, temperature, and weed invasion. Bendire's Thrashers are uncommon, and they require large, intact tracts of land with appropriate habitat features. In general, even under ideal habitat conditions, their populations are believed to have low densities across the landscape and territories may be widely dispersed. This presents a difficulty for conservation planning, as it is not as easy to pinpoint hotspots on the landscape where all conservation should be focused. The rarity of the species across the landscape already presents a risk to the population, and further stress from habitat fragmentation and reduced habitat quality may lead to a further fragmentation of the population and reduced reproductive success.

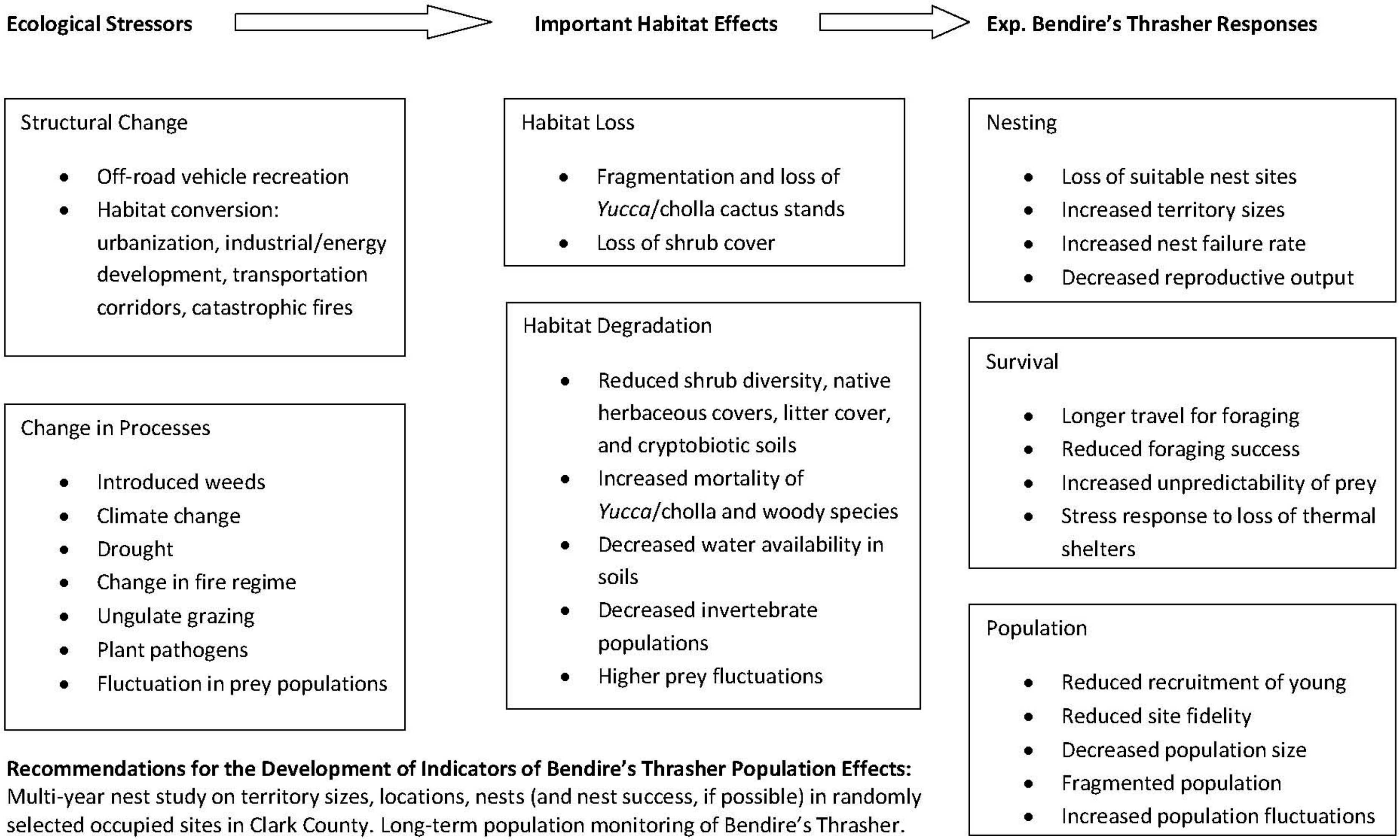

Figure 27. Bendire's Thrasher conceptual habitat model, Clark County.

Density and Population Estimates

Bendire's Thrashers were found primarily in Joshua tree and secondarily in mesquite-catclaw habitats (Table 20). Specifically, we recorded 0.03 detections of Bendire's Thrashers within the Joshua tree stratum and 0.04 detections/40 ha within mesquite-catclaw. Estimates with the double-sampling corrections resulted in densities of 0.14 birds/40 ha and 0.17 birds/40 ha, respectively. All of the confidence intervals included zero, and there were insufficient records to conduct removal analyses.

These numbers may be somewhat inflated, however, because the removal analyses for Le Conte's Thrashers (see section below on Le Conte's Thrasher), which also included Crissal Thrasher detections from non-riparian habitats, indicated a lack of population closure within 100 meters when using the 10-minute point count. Specifically, in the 9th and 10th minutes of the count, the number of thrasher detections increased. While this may be due to a delayed behavioral response (e.g., after the surveyor has been present for several minutes, shy individuals resume their normal behaviors), it is also possible that it is a result of new individuals moving from beyond 100 m into the survey plot. Through the 8th minute, however, the encounter histories appeared as expected in a closed population scenario. Because this pattern was evident in both the Le Conte's and Crissal Thrasher data, it is reasonable to expect a similar pattern in Bendire's Thrasher. Nonetheless, our results do suggest that we have more Bendire's Thrashers in Clark County than originally believed (GBBO 2010).

In central Arizona, Szaro and Jakle (1985) found Bendire's Thrasher densities averaging 0.9 birds per 40 ha in desert wash habitat, and 0.5 birds/40 ha in desert uplands. Near Tucson, Arizona, Emlen (1974) found Bendire's Thrashers at a density of approximately 0.2 bird/40 ha.

Table 20. Estimated density and population size of Bendire's Thrasher in Clark County by year and habitat stratum, 2008-2013.

Stratum	2008	2009	2010	2011	2012	2013	2012-2013	Overall (2003-2013)
Joshua Tree								
Raw density of detections		0.28 (0, 0.85)		0.28 (0, 0.85)		0.10 (0, 0.26)	0.04 (0, 0.09)	0.03 (0, 0.07)
Density Estimates (Double-Sampling)		1.24 (0, 3.74)		1.24 (0, 3.74)		0.45 (0, 1.12)	0.16 (0, 0.39)	0.14 (0, 0.30)
Raw population size estimate		5610.3 (0, 16833.8)		5610.3 (0, 16833.8)		2019.7 (0, 5056.1)	701.3 (0, 1744.8)	618.8 (0, 1368.1)
Population Size (Double-sampling)		24685.3 (0, 74068.8)		24685.3 (0, 74068.8)		8886.7 (0, 22246.8)	3085.7 (0, 7677.3)	2722.6 (0, 6019.7)
Mesquite-Catclaw								
Raw density of detections						0.06 (0, 0.19)	0.04 (0, 0.12)	0.04 (0, 0.12)
Density Estimates (Double-Sampling)						0.28 (0, 0.84)	0.18 (0, 0.52)	0.17 (0, 0.51)
Raw population size estimate						32.4 (0, 97.2)	20.2 (0, 60.6)	19.6 (0, 59.0)
Population Size (Double-sampling)						142.5 (0, 427.6)	89.1 (0, 266.4)	86.4 (0, 259.7)
Mojave Scrub								
Raw density of detections								0.01 (0, 0.03)
Density Estimates (Double-Sampling)								0.05 (0, 0.14)
Raw population size estimate								204.5 (0, 615.6)
Population Size (Double-sampling)								899.6 (0, 2708.6)
Total								
Population Size (Double-sampling)		24685.3		24685.3		9029.2	3174.7	3708.6

Habitat Use

Bendire's Thrasher occurs in mid-elevation Mojave scrub and is almost always associated with either *Yucca*/cholla stands or areas of increased shrub density, such as those present around ephemeral washes (Figure 28). The records of Bendire's Thrasher in mesquite-acacia transects are likely due to the species using these trees as the only tall singing perches available and mesquite-acacia often being adjacent to suitable breeding habitat. We are not aware of records of Bendire's Thrasher breeding in mesquite/acacia woodlands. Our findings of this study agree with earlier findings on Bendire's Thrasher by Fletcher et al. (2010) and Fletcher (2009).

Bendire's Thrasher requires nest substrates that are fairly solid, such as cactus, mesquite, or *Yucca*, and is likely not able to nest in pure creosote bush stands. As does the Le Conte's Thrasher, the species primarily sifts through the litter of native shrubs and forbs for invertebrates, which makes this species vulnerable to loss of native understory from a variety of threats and to invasive weeds.

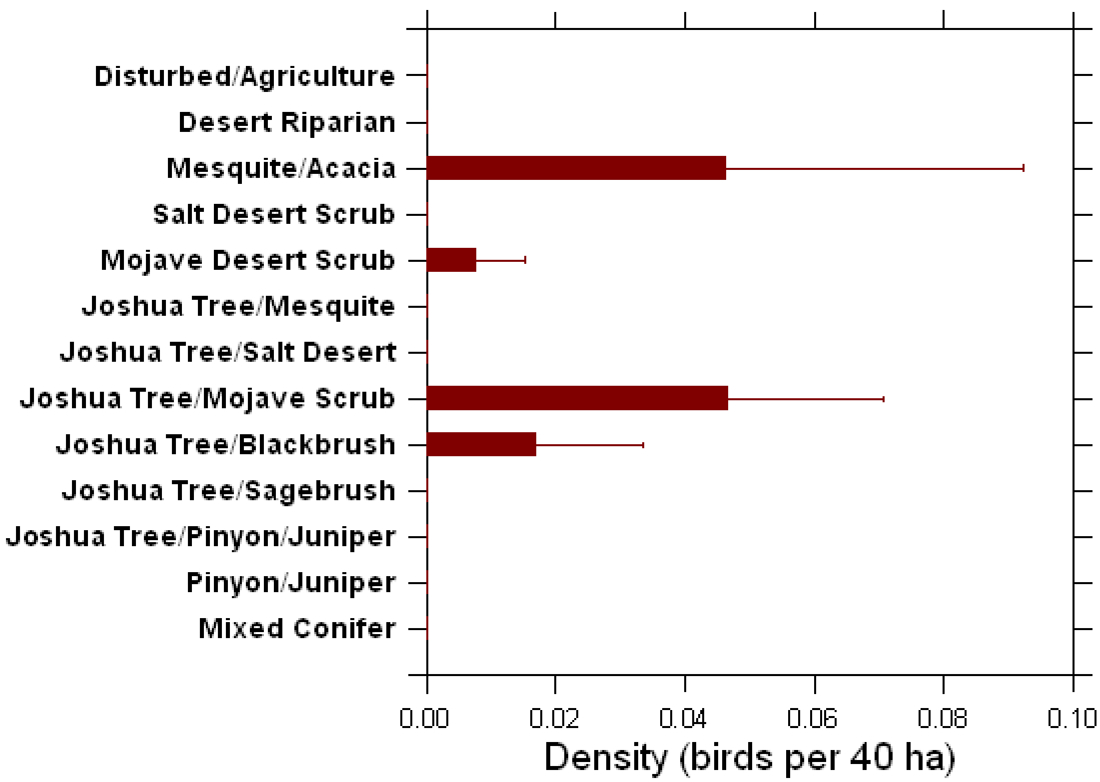

Figure 28. Estimated density (mean and standard error) of the Bendire's Thrasher at survey points in Clark County dominated by each GIS habitat grouping, from the Clark County habitat map (Heaton et al. 2011).

Observed Actual Distribution

Our combined records from surveys over the past 15 years reveal a very sparse distribution of Bendire's Thrasher in Clark County (Figure 29). Almost all records are from the elevational zone that includes Joshua tree and other *Yucca* species. Most records are from the southern half of Clark County's broad Joshua tree landscapes, but we know that the species ranges as far north as as southern Nye and Lincoln's counties (Floyd et al. 2007). The distribution map of Clark County indicates that, while sparsely populated, the species may occur in almost any area of Clark County that features its preferred habitats, including Joshua tree, other *Yucca* species, cholla cactus and a diversity of shrub species. Based on our data, it appears that the species is completely restricted to these habitat types and thus exposed to all threats that happen in the areas covered by these upper Mojave Desert biomes.

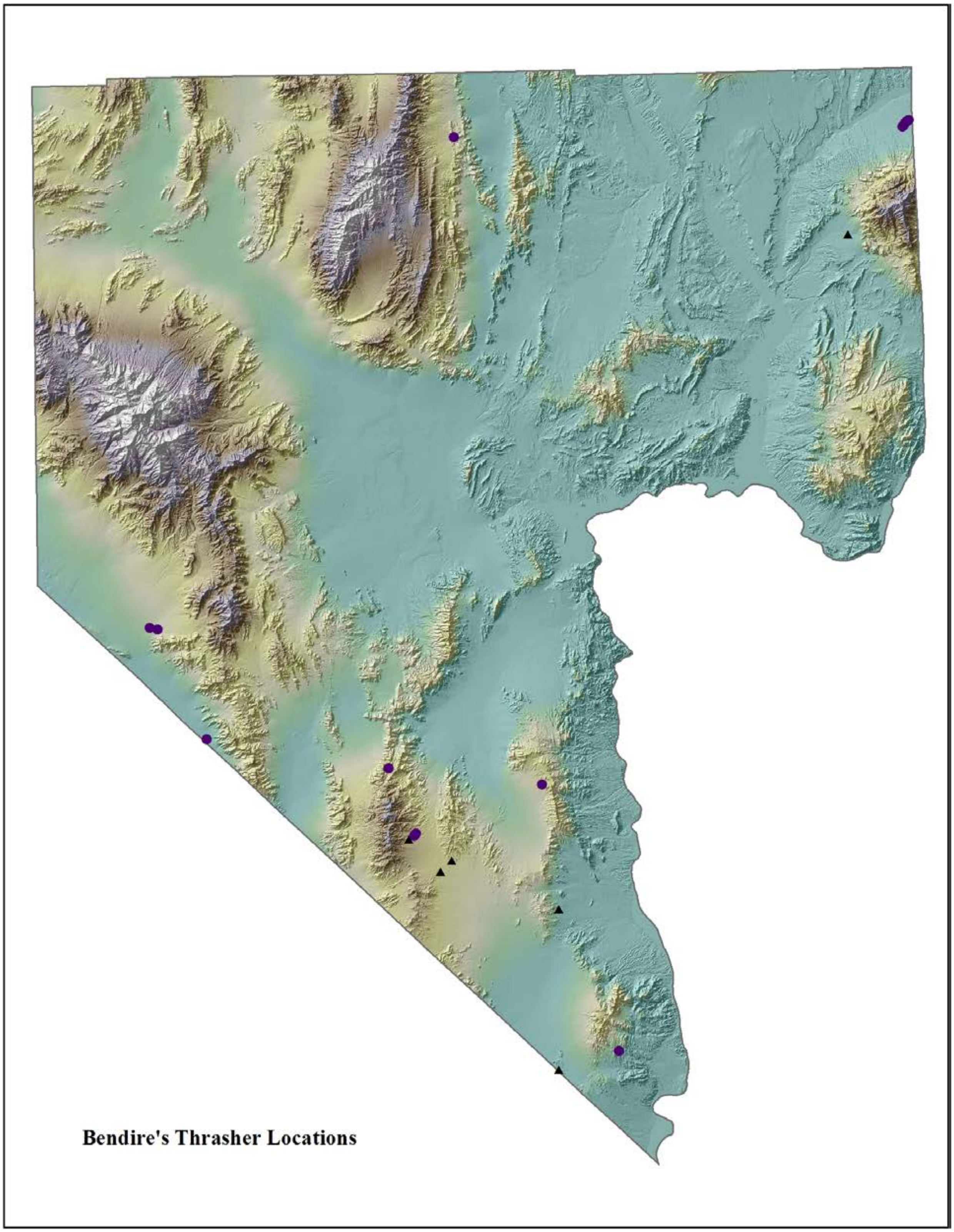

Figure 29. Bendire's Thrasher locations within Clark County. Circles indicate records at Nevada Bird Count transect points (2003-2013); triangles indicate Breeding Bird Atlas records (1998-2000).

Spatial Habitat Models

As observed in the actual distribution of Bendire's Thrasher in Clark County, the predicted distribution throughout Clark County indicates very broad swathes of land in which the species might occur in low densities (Figure 30). As cautioned with other predictive maps in this report, the final determination of the likelihood of Bendire's Thrasher populations being present in a given project site needs to be made on the ground and through determining whether suitable breeding habitats are present, as the species may occur anywhere in the county where these habitats are available.

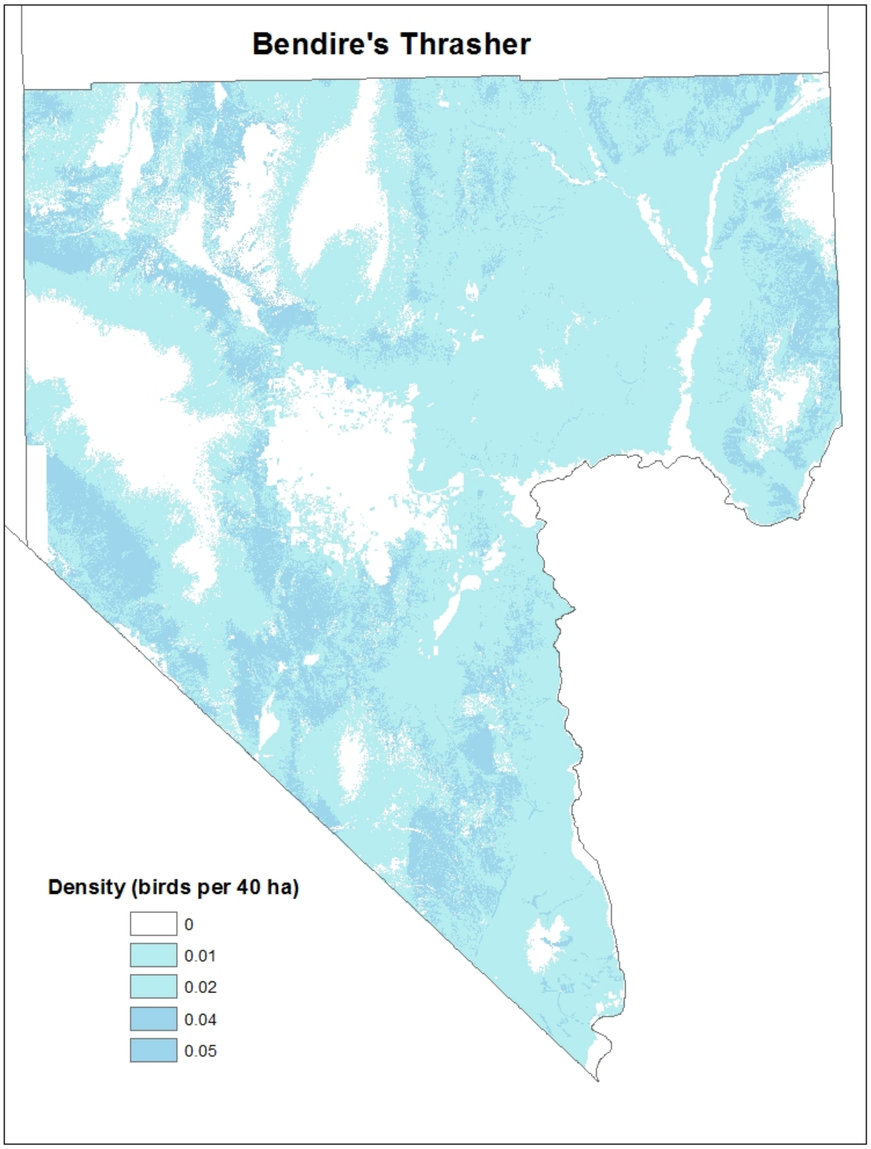

Figure 30. Predicted distribution of Bendire's Thrasher in Clark County. Mapped values represent the predicted density of the Bendire's Thrasher in each GIS habitat category from the Clark County habitat map (Heaton et al. 2011).

Gray Vireo (Evaluation Species)

Photo and Rights: Martin Meyers

Conceptual Model

The Gray Vireo is largely restricted to pinyon-juniper woodlands of the Mojave Desert, but may reach as far north as northern Lincoln County in Nevada (Floyd et al. 2007). In Clark County, it is therefore strictly a montane species that relies on dwarf coniferous woodlands with a shrub understory for breeding habitat. The main ecological stressors on this habitat include habitat conversion from developments and infrastructure, changes in fire regimes, and subtle processes such as climate change that slowly degrade the suitability of its preferred breeding habitat (Figure 31). Because Gray Vireo is an upland species, effects from gradual degradation may slowly accumulate to decrease its food resources, which include only insects and invertebrates. Gray Vireos are migratory, so any habitat effects in Clark County affect populations through their breeding habitat and in their breeding season.

Ecological Stressors → **Important Habitat Effects** → **Expected Gray Vireo Responses**

Ecological Stressors

Structural Change

- Off-road vehicle recreation
- Habitat conversion: urbanization, industrial/energy development, transportation corridors, catastrophic fires

Change in Processes

- Introduced weeds
- Climate change
- Drought
- Change in fire regime
- Plant pathogens
- Fluctuation in prey populations

Important Habitat Effects

Habitat Loss

- Fragmentation and loss of woodlands
- Loss of shrub cover

Habitat Degradation

- Loss of shrub diversity
- Increased tree canopy cover; decreased age class diversity
- Increased mortality in woody species
- Decreased water availability in soils and waterbodies
- Decreased invertebrate populations
- Higher prey fluctuations

Expected Gray Vireo Responses

Nesting

- Loss of suitable nest sites
- Increased territory sizes
- Increased nest failure rate
- Decreased reproductive output

Survival

- Longer travel for foraging
- Reduced foraging success
- Increased unpredictability of prey
- Stress response to loss of water and thermal shelters

Population

- Reduced recruitment of young
- Reduced site fidelity
- Decreased population size
- Fragmented population
- Increased population fluctuations

Recommendations for the Development of Indicators of Gray Vireo Population Effects:
Baseline data on territory sizes, locations, nests (and nest success, if possible) in randomly selected occupied sites in Clark County. Research on prey use and availability to develop a simple indicator prey species monitoring plan. Long-term population monitoring of Gray Vireos.

Figure 31. Gray Vireo conceptual habitat model, Clark County.

Density and Population Estimates

Gray Vireos are found primarily in pinyon-juniper transects, with occasional detections in the coniferous forest and sagebrush strata that often have significant pinyon-juniper within their boundaries (Table 21). Gray Vireos are also occasional found where Joshua tree habitats abut pinyon-juniper. Rare records from lowland riparian and Mojave scrub are likely from migrants.

In its preferred habitats, we detected 0.79 Gray Vireos/40 ha in coniferous forest, 1.69 Gray Vireos/40 ha in pinyon-juniper, and 2.05 birds/40 ha in the sagebrush stratum, and all three of these strata's confidence intervals overlapped. Removal-based estimates were either relatively similar to the raw densities, or intermediate between the raw and double-sampling estimates, for all strata analyzed. The double-sampling estimates were larger than those from the raw data and removal analyses, and for several strata, the 95% confidence intervals did not overlap. The removal estimates tended to have the narrowest confidence intervals of the three methods. Densities of Gray Vireos in other studies ranged from 1.8 to 2.4 birds/40 ha (Wickersham and Wickersham 2009).

In 2012/2013, we found an estimated density of 1.78 birds/40 ha in the sagebrush stratum, which commonly also contains pinyon-juniper in Clark County. This and other evidence indicates that the species relies on a significant shrub layer that is interspersed with the trees of the pinyon-juniper zone.

Table 21. Estimated density and population size of Gray Vireos in Clark County by year and habitat stratum, 2008-2013.

Stratum	2008	2009	2010	2011	2012	2013	2012-2013	Overall (2003-2013)
Coniferous Forest								
Raw density of detections	0.32 (0, 0.96)		2.12 (0, 6.37)		0.76 (0.26, 1.27)	2.55 (N/A)	1.06 (0.42, 1.70)	0.79 (0.34, 1.28)
Density Estimates (Double-Sampling)	0.98 (0, 2.94)		6.54 (0, 19.61)		2.35 (0.79, 3.92)	7.84 (N/A)	3.27 (1.31, 5.23)	2.43 (1.05, 3.93)
Density Estimates (Removal)	N/A		N/A		N/A	N/A	N/A	0.44 (0.36, 0.99)
Raw population size estimate	352.3 (0, 1056.9)		2348.5 (0, 7045.0)		845.5 (282.2, 1408.8)	2818.2 (N/A)	1174.2 (469.2, 1879.1)	872.4 (377.4, 1411.0)
Population Size (Double-sampling)	1085.0 (0, 3255.1)		7233.3 (0, 21698.6)		2604.0 (869.2, 4339.0)	8680.0 (N/A)	3616.7 (1445.2, 5787.7)	2687.0 (1162.3, 4345.9)
Population Size (Removal Modeling)	N/A		N/A		N/A	N/A	N/A	486.6 (400.2, 1100.3)
Joshua Tree								
Raw density of detections						0.10 (0, 0.26)	0.07 (0, 0.18)	0.10 (0.02, 0.20)
Density Estimates (Double-Sampling)						0.31 (0, 0.79)	0.22 (0, 0.55)	0.31 (0.08, 0.62)
Density Estimates (Removal)						N/A	N/A	0.08 (0.07, 0.18)
Raw population size estimate						2019.7 (0, 5056.1)	1402.6 (0, 3509.5)	1998.4 (495.7, 3985.4)
Population Size (Double-sampling)						6220.7 (0, 15572.8)	4319.9 (0, 10809.3)	6155.2 (1526.7, 12275.0)
Population Size (Removal Modeling)						N/A	N/A	1583.5 (1302.1, 3581.1)

Stratum	2008	2009	2010	2011	2012	2013	2012-2013	Overall (2003-2013)
Lowland Riparian								
Raw density of detections								0.00 (0, 0.01)
Density Estimates (Double-Sampling)								0.01 (0, 0.02)
Raw population size estimate								0.4 (0, 1.2)
Population Size (Double-sampling)								1.3 (0, 3.9)
Mojave Scrub								
Raw density of detections	0.36 (0, 1.09)							0.04 (0, 0.10)
Density Estimates (Double-Sampling)	1.12 (0, 3.36)							0.12 (0, 0.30)
Density Estimates (Removal)	N/A							0.07 (0.06, 0.18)
Raw population size estimate	7224.1 (0, 21664.8)							775.2 (0, 1965.9)
Population Size (Double-sampling)	22250.3 (0, 66727.7)							2387.7 (0, 6055.0)
Population Size (Removal Modeling)	N/A							1457.7 (1193.5, 3596.5)
Pinyon-Juniper								
Raw density of detections	1.27 (0, 2.73)	2.24 (0.89, 3.63)	1.70 (0.64, 2.97)	2.24 (0.89, 3.63)	0.25 (0, 0.51)	2.17 (1.27, 3.04)	1.43 (0.81, 2.12)	1.69 (1.05, 2.42)
Density Estimates (Double-Sampling)	3.92 (0, 8.40	6.89 (2.75, 11.17)	5.23 (1.96, 9.15)	6.89 (2.75, 11.17)	0.78 (0, 1.57)	6.68 (3.92, 9.38)	4.41 (2.49, 6.52)	5.19 (3.25, 7.45)
Density Estimates (Removal)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2.22 (2.00, 3.01)
Raw population size estimate	3827.2 (0, 8200.0)	6727.9 (2687.1, 10904.9)	5102.9 (1914.7, 8930.1)	6727.9 (2687, 10904.9)	765.4 (0, 1529.9)	6518.1 (3826.3, 9149.5)	4305.5 (2428.6, 6366.2)	5064.9 (3168.1, 7273.9)
Population Size (Double-sampling)	11787.6 (0, 25255.0)	20721.9 (8276.4, 33587.0)	15716.8 (5897.2, 27504.6)	20721.9 (8276.4, 33587.0)	2357.5 (0, 4712.2)	20075.8 (11785.1, 28180.5)	13261.1 (7480.2, 19607.8)	15600.0 (9757.6, 22403.6)
Population Size (Removal)	N/A	N/A	N/A	N/A	N/A	N/	N/A	6658.6 (6023.0, 9059.0)

Stratum	2008	2009	2010	2011	2012	2013	2012-2013	Overall (2003-2013)
Sagebrush								
Raw density of detections	0.64 (0, 1.27)	1.27 (0, 2.55)		1.27 (0, 2.55)	3.82 (0.85, 6.79)		2.29 (0, 5.35)	2.05 (0.41, 4.41)
Density Estimates (Double-Sampling)	1.96 (0, 3.92)	3.92 (0, 7.84)		3.92 (0, 7.84)	1.77 (2.61, 20.92)		7.06 (0, 16.47)	6.30 (1.26, 13.59)
Density Estimates (Removal)	N/A	N/A		N/A	N/A		N/A	1.78 (1.62, 2.89)
Raw population size estimate	64.94 (0, 129.8)	129.9 (0, 259.8)		129.9 (0, 259.8)	389.6 (86.6, 692.7)		233.8 (0, 545.5)	208.7 (41.7, 449.9)
Population Size (Double-sampling)	200.0 (0, 399.9)	400.0 (0, 800.1)		400.0 (0, 800.1)	1200.0 (266.7, 2133.4)		720.0 (0, 1680.1)	642.9 (128.5, 1385.7)
Population Size (Removal Modeling)	N/A	N/A		N/A	N/A		N/A	181.9 (165.2, 294.3)
Total								
Population Size (Double-sampling) / (Removal)	35322.9	21121.9	22950.2	21121.9	6161.5	34976.5	21917.7	27473.9 / 10368.2

Habitat Use

The Gray Vireo resides primarily in pinyon-juniper woodlands of the southwest. While it is most often observed in the tree canopy, where it nests, it likely requires both multi-aged, open, park-like stands and an ample shrub understory for foraging (Figure 32; GBBO 2010). Most Gray Vireo records from outside the pinyon-juniper zone are from the mixed Joshua tree zone that is just below the pinyon-juniper belt in elevation (Figure 29). As seen in the actual distribution map below, this transitional lower-elevation zone of the pinyon-juniper belt appears to be where indeed most Gray Vireo records were located. These results are comparable to other studies from the region, where Gray Vireos reportedly breed most commonly in pinyon-juniper habitats with an oak or chaparral element (Barlow et al. 1999). Some publications reported that they may prefer young pinyon-juniper stands (Wickersham and Wickersham 2009), while others reported the use of juniper stands that were 60-180 years old, with nest trees averaging 120 years old (Frei 2008). One study suggests that Gray Vireos favor juniper trees over pinyon pine for nesting (Francis et al. 2013). Gray Vireos also require fairly large breeding territories, most likely because prey species are scarce and unpredictable.

Stands that are most often occupied by Gray Vireo are on south facing slopes and contain at least some old-growth features. This species is still poorly studied throughout its range, and much of its nesting biology remains unknown.

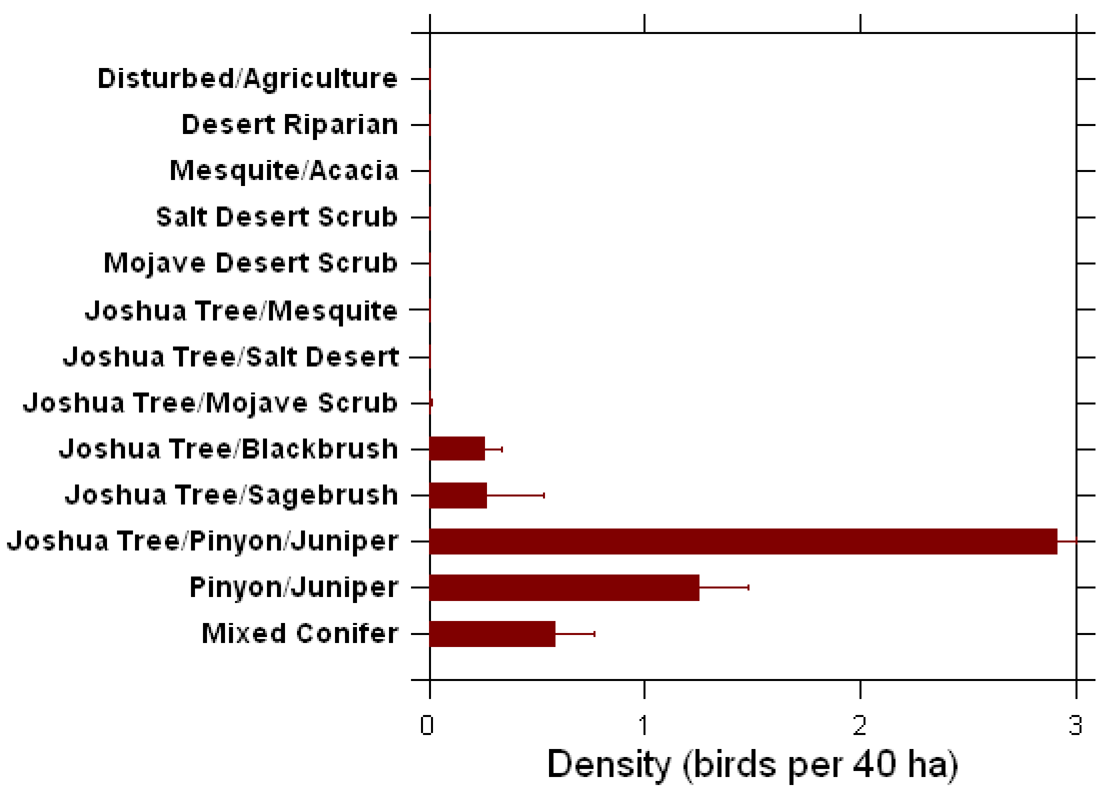

Figure 32. Estimated density (mean and standard error) of the Gray Vireo at survey points in Clark County dominated by each GIS habitat grouping, from the Clark County habitat map (Heaton et al. 2011).

Statistical Habitat Model

In our habitat assessments, we found that Gray Vireo densities were significantly higher in plots that had no roads within 400 m, no developments within 1000 m, plots that do have a dry wash within the plot, plots with coniferous trees or any trees within 1000 m, and plots without riparian shrubs (Table 22). Based on dominant plant species, Gray Vireo densities were higher where Joshua tree, Mojave yucca, pinyon pine, juniper, cliffrose, creosote, or sagebrush were present than where they were absent, and their densities were higher where mesquite, acacia, and tamarisk were absent.

Table 22. Comparison of estimated densities (birds per 40 ha) for Gray Vireo, with and without selected habitat or landscape elements, along with p-values from the ANOVA tests.

	Absent	**Present**	**ANOVA p-value**
Roads within 400 m	0.52	0.31	0.05
Development 1000 m	0.47	0.13	0.02
Water within 100 m	0.44	0.15	0.13
Water within 1000 m	0.46	0.19	0.06
Dry Wash within 100 m	0.26	0.48	0.05
Trees within 100 m	0.04	0.62	0.00
Deciduous trees	0.39	0.61	0.21
Coniferous trees	0.03	1.81	0.00
Trees within 1000 m	0.01	0.56	0.00
Riparian Shrub within 100 m	0.46	0.13	0.03
Grazing within 100 m	0.40	0.47	0.62
Tall cholla within 100 m	0.46	0.24	0.07
Mistletoe within 100 m	0.36	0.56	0.09
From plant species lists (all within 100 m):			
Joshua Tree	0.31	0.65	0.00
Mojave Yucca	0.55	0.08	0.00
Acacia	0.55	0.03	0.00
Mesquite	0.46	0.00	0.01
Pinyon Pine	0.07	2.20	0.00
Juniper	0.06	1.98	0.00
Willow	0.42	0.06	0.24
Tamarisk	0.46	0.00	0.01
Creosote	0.98	0.02	0.00
Saltbush	0.45	0.24	0.10
Cliffrose	0.18	2.46	0.00
Sagebrush	0.13	2.00	0.00
Cottonwood	0.42	0.15	0.50

In our logistic regression analyses, we found that Gray Vireos occurred at a significantly higher elevation than other surveyed sites (mean Gray Vireo elevation = 5,733 ft), that plant densities in used plots was higher in all height categories below 10 m than in unused plots, but that it was significantly lower at a > 10 m height in used than in unused plots, and that pinyon pine and juniper proportions were significantly higher in used than in unused plots (Table 23). Unused plots had a higher proportion of Mojave yucca, acacia, tamarisk, and creosote than did used plots (Table 23). These results correspond well with other studies in the region, where Gray Vireos have been found in open pinyon-juniper woodlands and montane shrublands, tending towards lower-elevation pinyon-juniper, and where sagebrush is prevalent (Schlossberg 2006, Barlow et al. 1999). Wickersham and Wickersham (2007) also found that occupied habitat contained fewer trees taller than 4 m than did random locations. We found sites with Gray Vireos had greater numbers of trees in the 4 to10 m height range, and fewer trees greater than 10 m tall than did non-use sites. However, as did Wickersham and Wickersham (2007), we found a large density difference in the 1.5 to 4 m plant height category, with sites used by Gray Vireo being associated with higher densities of woody plants than unused sites.

Table 23. Logistic regression results for habitat models predicting Gray Vireo occurrence (detected on 39 points), with mean and standard error of the variables at points with or without detections the species. All variables except elevation are derived from point-centered-quarter plotless sampling.

	Species not detected	Species detected	coefficient	p-value	R^2
Elevation in feet	3,322 ±40	5,733 ±104	+	0.00	0.22
Plant Density at 0 to 0.5 m height	4,234 ±190	6,199 ±990	+	0.03	0.01
Plant Density at 0.5 to 1.5 m height	1,112 ±42	1,523 ±196	+	0.04	0.01
Plant Density at 1.5 to 4 m height	186 ±11.7	305 ±30	+	0.04	0.01
Plant Density at 4 to 10 m height	12.7 ±1.6	46.6 ±8.0	+	0.01	0.01
Plant Density at > 10 m height	5.2 ±2.9	0.9 ±0.3	-	0.60	0.00
Joshua Tree (proportion of density)	0.054 ±0.003	0.032 ±0.008	-	0.08	0.01
Mojave Yucca (proportion of density)	0.032 ±0.002	0.005 ±0.002	-	0.00	0.03
Acacia (proportion of density)	0.035 ±0.002	0.002 ±0.002	-	0.01	0.04
Mesquite (proportion of density)	0.014 ±0.002	0.076 ±0.022	+	0.14	0.01
Tamarisk (proportion of density)	0.040 ±0.004	0.00	-	0.00	0.03
Creosote (proportion of density)	0.202 ±0.005	0.007 ±0.004	-	0.00	0.18
Saltbush (proportion of density)	0.034 ±0.003	0.005 ±0.002	-	0.06	0.02
Blackbrush (proportion of density)	0.036 ±0.002	0.032 ±0.008	-	0.72	0.00
Pinyon Pine (proportion of density)	0.035 ±0.002	0.244 ±0.009	+	0.00	0.22
Juniper (proportion of density)	0.019 ±0.001	0.109 ±0.008	+	0.00	0.15

Observed Actual Distribution

Aside from a few scattered records across Clark County's lowland habitats, which likely represent migrant individuals, Gray Vireo is clearly restricted to the pinyon-juniper zone and its lower-elevation transitional habitat types in Clark County (Figure 33). It is particularly notable that, while Gray Vireos do seem to occur throughout the montane coniferous belt, the highest montane elevations are largely devoid of Gray Vireo. We therefore assume that their optimal habitats are located either squarely in the pinyon-juniper belt area or even slightly below it, where it transitions into Joshua tree and blackbrush in Clark County, which is also supported by our habitat data.

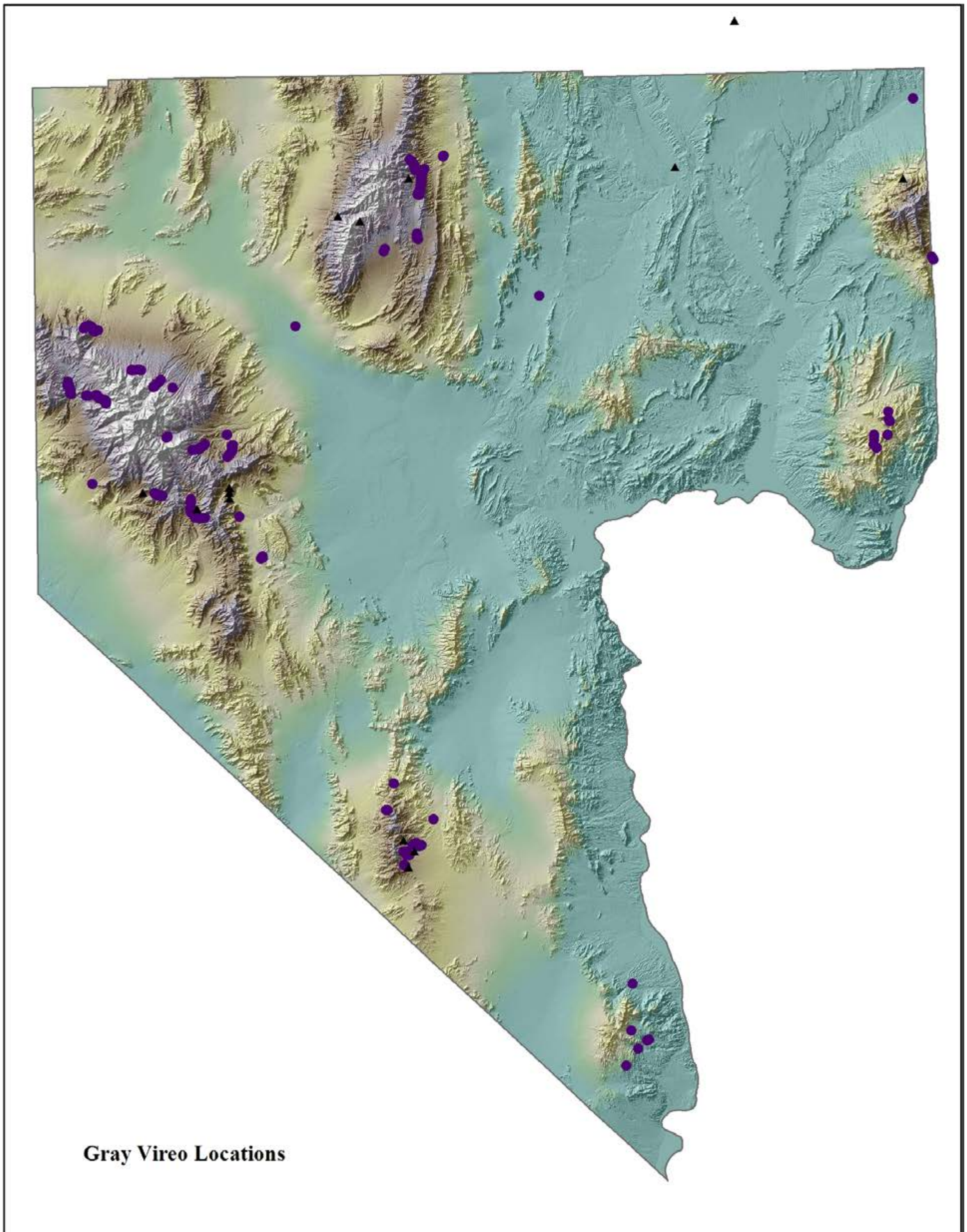

Figure 33. Gray Vireo locations within Clark County. Circles indicate records at Nevada Bird Count transect points (2003-2013); triangles indicate Breeding Bird Atlas records (1998-2000).

Spatial Habitat Models

Our spatial habitat model for Clark County indicates what the actual Gray Vireo distribution already suggests, that the species is restricted to the pinyon-juniper belt around the mountain ranges in the county with some additional areas in the elevational zone just beneath the pinyon-juniper belt (Figure 34). This suggests that conservation planning can focus entirely on these hotspot areas of Clark County, and as with all predictive models, local habitat features and conditions will determine the possibility of a particular project location being in Gray Vireo breeding habitat. Our regional spatial habitat model (Figure 35) suggests a broader landscape occupancy of Gray Vireos, which is likely due to the fact that migrants and wandering breeding individuals were picked up in surveys of other habitat types and at lower elevations.

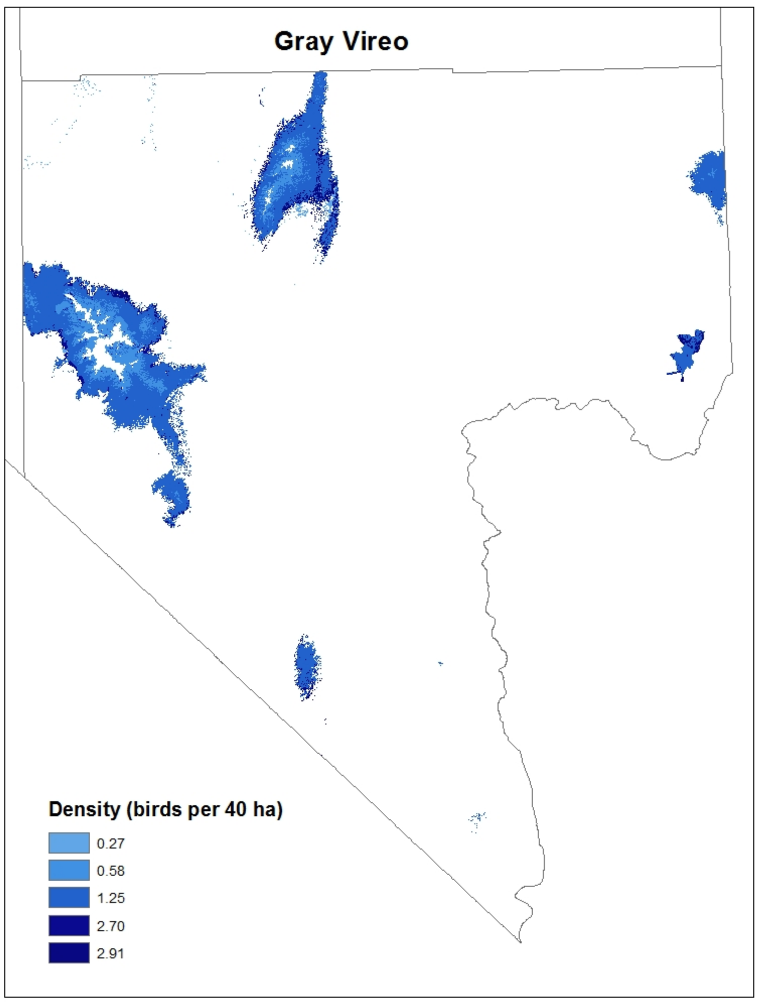

Figure 34. Predicted distribution of Gray Vireo in Clark County. Mapped values represent the predicted density of the Gray Vireo in each GIS habitat category from the Clark County habitat map.

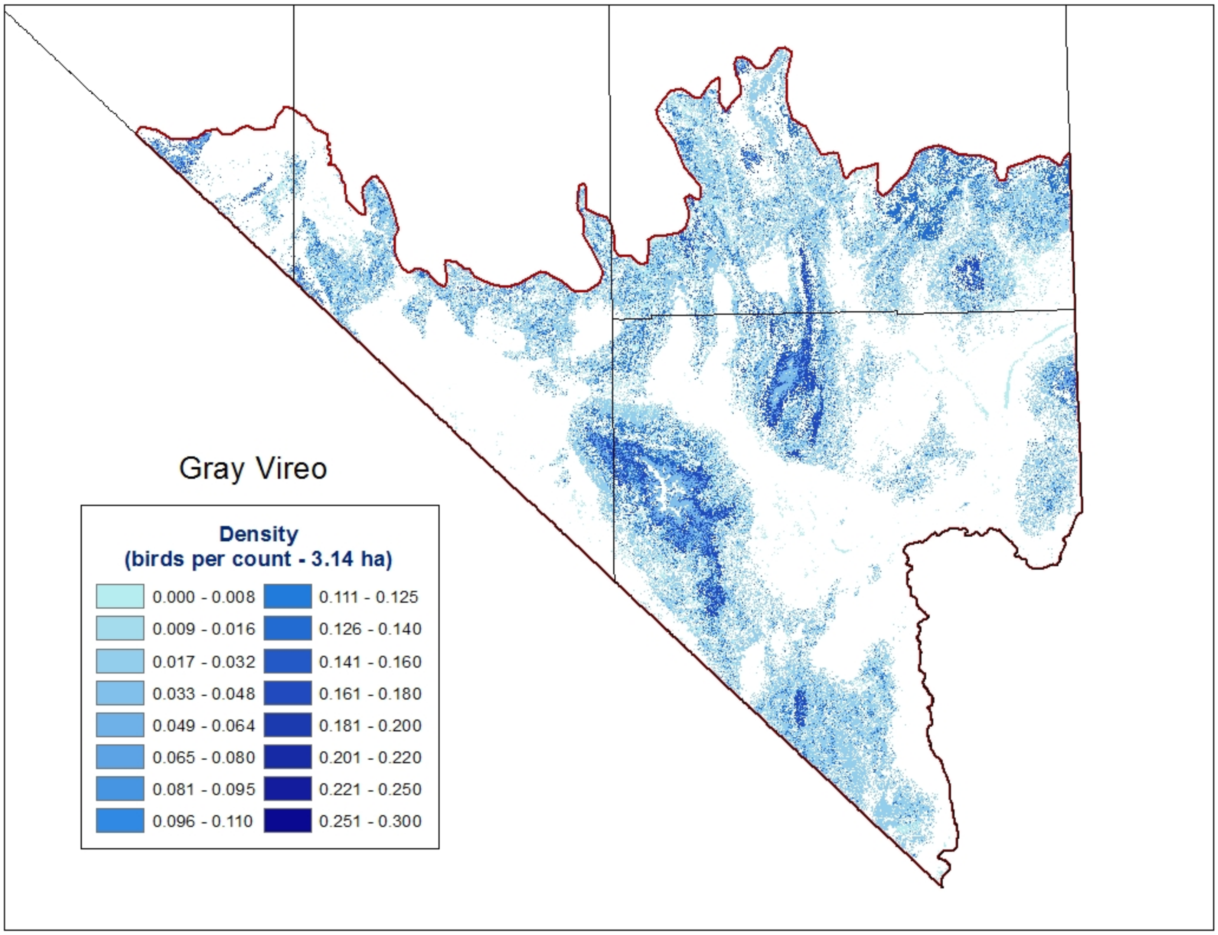

Figure 35. Predicted distribution of Gray Vireo in Clark County and the surrounding Mojave Desert. Mapped values are derived from the mean abundance per point count in habitat categories according to Provencher and Anderson (2011).

Le Conte's Thrasher (Evaluation Species)

Photo and Rights: Dawn Fletcher

Conceptual Model

Le Conte's Thrasher is a species of low-elevation upland habitats in the Mojave Desert. It can survive for prolonged periods without access to water, because it can gain metabolic water from its prey. As such, the species' conservation planning is not centered on water availability, as is the case for all MSHCP covered species, but more on upland habitat integrity, threats from land developments and infrastructure, and fragmentation of the desert landscape. Specific ecological stressors that act on Le Conte's Thrasher habitat include habitat conversion, threats from invasive annual plants, changing fire regimes, and the gradual changes in habitat quality associated with climate change (Figure 36). Le Conte's Thrashers are already naturally sparsely distributed in the Mojave Desert, most likely due to their specialization on ephemeral food resources. Therefore, a species specialized on "living on the edge" may be most threatened in its population status by artificial changes to its habitats that jeopardize its already scarce resources.

Ecological Stressors → **Important Habitat Effects** → **Exp. Le Conte's Thrasher Responses**

Ecological Stressors

Structural Change

- Off-road vehicle recreation
- Habitat conversion: urbanization, industrial/energy development, transportation corridors, catastrophic fires

Change in Processes

- Introduced weeds
- Climate change
- Drought
- Change in fire regime
- Ungulate grazing
- Plant pathogens
- Fluctuation in prey populations

Important Habitat Effects

Habitat Loss

- Fragmentation and loss of *Yucca*/cholla cactus stands and high-occupancy salt desert sites
- Loss of shrub cover

Habitat Degradation

- Reduced shrub diversity, native herbaceous covers, litter cover, and cryptobiotic soils
- Increased mortality of *Yucca*/cholla and woody species
- Decreased water availability in soils
- Decreased invertebrate populations
- Higher prey fluctuations

Exp. Le Conte's Thrasher Responses

Nesting

- Loss of suitable nest sites
- Increased territory sizes
- Increased nest failure rate
- Decreased reproductive output

Survival

- Longer travel for foraging
- Reduced foraging success
- Increased unpredictability of prey
- Stress response to loss of thermal shelters

Population

- Reduced recruitment of young
- Reduced site fidelity
- Decreased population size
- Fragmented population
- Increased population fluctuations

Recommendations for the Development of Indicators of Le Conte's Thrasher Population Effects: Multi-year nest study on territory sizes, locations, nests (and nest success, if possible) in randomly selected occupied sites in Clark County. Long-term population monitoring of Le Conte's Thrasher.

Figure 363. Le Conte's Thrasher conceptual habitat model, Clark County.

Density and Population Estimates

Le Conte's Thrashers were found most reliably in mesquite-catclaw and Mojave scrub, with scattered detections in salt desert and Joshua tree (Table 24). One pinyon-juniper transect bordering Joshua tree woodlands also contained some individuals. Overall, we recorded 0.14 birds/40 ha within the Joshua tree stratum, 0.44 birds/40 ha within the mesquite-catclaw stratum, and 0.24 birds/40 ha within the Mojave scrub stratum.

The removal analysis results indicated that these numbers may be somewhat inflated, however. First, the removal analyses for Le Conte's Thrashers (which also included Crissal Thrasher detections from non-riparian habitats) indicated a lack of population closure within 100 meters when using the 10-minute point count. Specifically, in the 9th and 10th minutes of the count, the number of thrasher detections increased. While this may be due to a delayed behavioral response (e.g., after the surveyor has been present for several minutes, shy individuals resume their normal behaviors), it is also possible that it is a result of new individuals moving from beyond 100 m into the survey plot. Through the 8th minute, however, the encounter histories appeared as expected in a closed population scenario. We therefore used for the removal analyses for the Le Conte's Thrasher only data through 8 minutes of the count to better meet the assumption of a closed population.

Second, there were sufficient detections in the mesquite-catclaw stratum to use removal models incorporating heterogeneity of detection probabilities. The estimated density of Le Conte's Thrashers within this stratum using heterogeneity modeling was 0.47 birds/40 ha (0.41, 1.08); without the heterogeneity modeling, it was 1.21 birds/40 ha (0.43, 23.71).

Due to the low number of area search plots containing Le Conte's Thrashers, the removal estimates are therefore likely more reliable than estimates derived from double-sampling. However, the limited data set resulted in very wide confidence intervals for all strata except mesquite-catclaw.

Using the removal results from the primary three strata, we estimate 4,673 Le Conte's Thrashers in Joshua tree, 239 birds in mesquite-catclaw, and 5,740 birds in Mojave scrub. Therefore, even when only considering the lower bound of the confidence intervals for these three strata, the minimum estimated population for Clark County would be 3,944 birds based on these data, suggesting that more Le Conte's Thrashers reside in Clark County than originally believed (GBBO 2010).

Other studies from the region report that Le Conte's Thrashers most often occur in sparsely-vegetated desert upland sites, such as areas with saltbush (*Atriplex* spp.) or cholla cactus, with an estimated density of fewer than 0.16 birds/40 ha across their range and maximum densities of 4.12 birds/40 ha in some areas (Sheppard 1996). In the Sonoran Desert, Le Conte's Thrasher has occasionally been reported in even higher estimated densities (4.0 birds/40 ha in dense Sonoran creosote, and 16.6 birds/40 ha in Palo Verde habitats; Franzreb 1978).

Table 24. Estimated density and population size of Le Conte's Thrashers in Clark County by year and habitat stratum, 2008-2013.

Stratum	2008	2009	2010	2011	2012	2013	2012-2013	Overall (2003-2013)
Joshua Tree								
Raw density of detections						0.20 (0.05, 0.41)	0.12 (0.02, 0.25)	0.14 (0.05, 0.25)
Density Estimates (Double-Sampling)						0.84 (0.21, 1.68)	0.51 (0.07, 1.02)	0.58 (0.21, 1.04)
Density Estimates (Removal)						N/A	N/A	0.24 (0.08, 4.64)
Raw population size estimate						4039.4 (1011.2, 8069.9)	2454.5 (356.9, 4917.3)	2784.5 (991.4, 5016.4)
Population Size (Double-sampling)						16642.4 (4166.2, 33248.1)	10112.6 (1470.4, 20259.3)	11472.2 (4084.5, 20667.7)
Population Size (Removal Modeling)						N/A	N/A	4673.1 (1676.6, 91937.5)
Mesquite-Catclaw								
Raw density of detections					0.27 (0, 0.82)	0.70 (0.12, 1.40)	0.46 (0.08, 0.94)	0.44 (0.08, 0.91)
Density Estimates (Double-Sampling)					1.12 (0, 3.37)	2.89 (0.52, 5.77)	1.89 (0.33, 3.85)	1.83 (0.32, 3.74)
Density Estimates (Removal)					N/A	N/A	N/A	0.47 (0.41, 1.08)
Raw population size estimate					138.8 (0, 416.7)	356.3 (64.6, 712.9)	232.8 (40.7, 475.8)	225.8 (39.2, 461.5)
Population Size (Double-sampling)					572.0 (0, 1717.0)	1468.1 (266.2, 2937.1)	959.3 (167.7, 1960.2)	930.2 (161.4, 1901.5)
Population Size (Removal Modeling)					N/A	N/A	N/A	238.8 (209.8, 547.9)

Stratum	2008	2009	2010	2011	2012	2013	2012-2013	Overall (2003-2013)
Mojave Scrub								
Raw density of detections					0.15 (0, 0.37)	0.12 (0, 0.30)	0.13 (0.03, 0.27)	0.24 (0.08, 0.44)
Density Estimates (Double-Sampling)					0.62 (0, 1.54)	0.50 (0, 1.25)	0.55 (0.14, 1.10)	1.00 (0.33, 1.83)
Density Estimates (Removal)					N/A	N/A	N/A	0.29 (0.10, 5.69)
Raw population size estimate					2974.6 (0, 7426.8)	2408.0 (0, 6016.9)	2661.5 (675.2, 5321.9)	4804.7 (1608.5, 8816.8)
Population Size (Double-sampling)					12255.5 (0, 30598.4)	9921.1 (0, 24789.6)	10965.5 (2781.7, 21926.2)	19795.5 (6626.9, 36325.4)
Population Size (Removal Modeling)					N/A	N/A	N/A	5740.1 (2058.0, 113010.1)
Pinyon-Juniper								
Raw density of detections		0.11 (0, 0.32)		0.11 (0, 0.32)				0.00 (0, 0.01)
Density Estimates (Double-Sampling)		0.44 (0, 1.31)		0.11 (0, 1.31)				0.01 (0, 0.04)
Raw population size estimate		318.9 (0, 955.8)		318.9 (0, 955.8)				8.6 (0, 27.1)
Population Size (Double-sampling)		1314.0 (0, 3938.1)		1314.0 (0, 3938.1)				35.5 (0, 111.5)
Population Size (Removal Modeling)		N/A		N/A				N/A

Stratum	2008	2009	2010	2011	2012	2013	2012-2013	Overall (2003-2013)
Salt Desert								
Raw density of detections					0.28 (0, 0.85)		0.23 (0, 0.70)	0.47 (0, 0.98)
Density Estimates (Double-Sampling)					1.17 (0, 3.50)		0.95 (0, 2.86)	1.95 (0, 4.03)
Density Estimates (Removal)					N/A		N/A	0.23 (0.08, 4.60)
Raw population size estimate					348.9 (0, 1046.7)		285.4 (0, 856.9)	583.3 (0, 1207.0)
Population Size (Double-sampling)					1437.3 (0, 4312.6)		1176.0 (0, 3530.3)	2404.7 (0, 4973.0)
Population Size (Removal Modeling)					N/A		N/A	278.3 (99.6, 5667.7)
Total								
Population Size (Double-sampling) / (Removal)		1314.0		1314.0	14264.8	28031.6	23213.3	34638.1 / 10930.3

Habitat Use

Le Conte's Thrasher is similar in its basic biology to the Bendire's Thrasher, but occurs in slightly larger populations in Nevada. Like Bendire's, Le Conte's Thrasher can be found in *Yucca*/cholla communities, but it often also occurs in low-elevation salt deserts that feature occasional stands of dense shrubs or ephemeral washes (Figure 37). Its foraging ecology is similar to Bendire's Thrasher, and both thrashers are fairly independent of the need to access water and their prey populations likely require healthy native understory plants for survival (Fletcher 2009, Fletcher et al. 2010).

Our records of Le Conte's Thrasher in mesquite-acacia transects are likely due to the birds using these taller woodlands as singing perches, particularly when these were adjacent to suitable upland breeding habitat. We know of no instances where Le Conte's Thrasher was observed nesting within mesquite-acacia habitat.

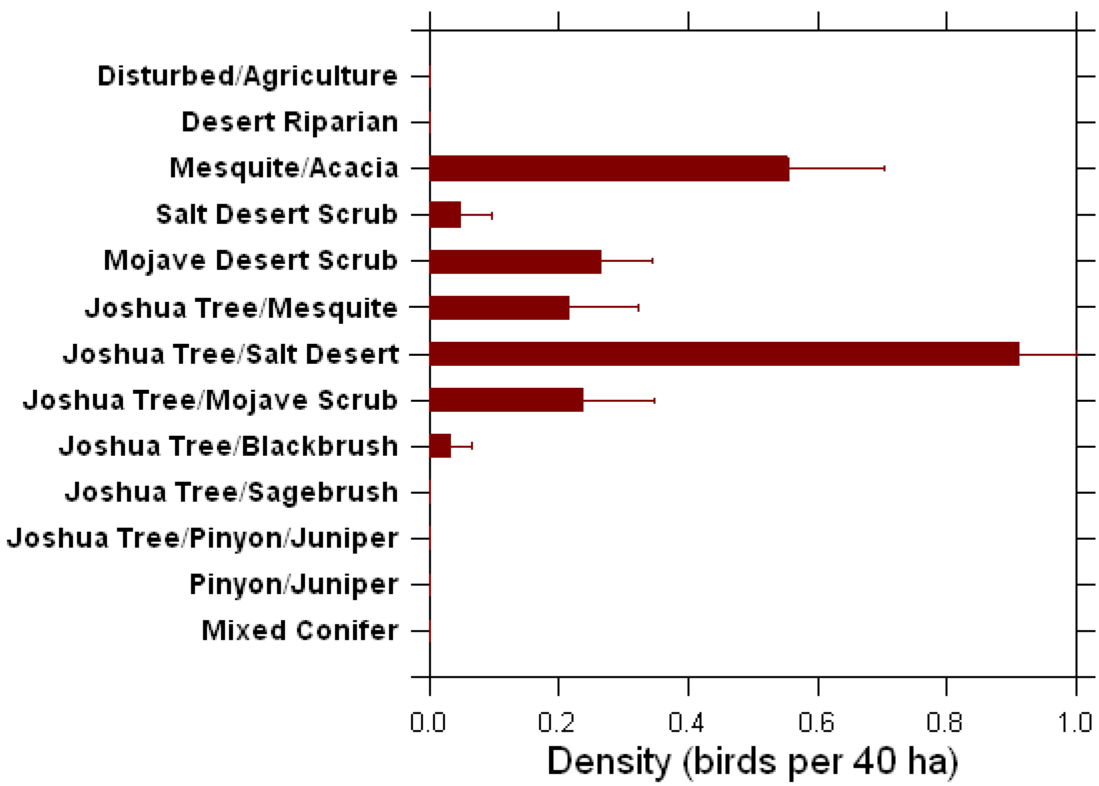

Figure 37. Estimated density (mean and standard error) of the Le Conte's Thrasher at survey points in Clark County dominated by each GIS habitat grouping, from the Clark County habitat map (Heaton et al. 2011).

Statistical Habitat Model

In our ANOVA analyses, we found that Le Conte's Thrashers in Clark County have higher densities in sites that have mistletoe within the plot and that are not grazed, but lower densities where coniferous trees were present than in sites that do not have these features (Table 25). When comparing densities among plots with dominant plant species present, Le Conte's Thrasher densities were lower in plots with Joshua trees, pinyon pine, juniper present, but higher in plots with acacia or creosote than in plots without these features.

Table 25. Comparison of estimated densities (birds per 40 ha) for Le Conte's Thrasher, with and without selected habitat or landscape elements, along with p-values from the ANOVA tests.

	Absent	Present	ANOVA p-value
Roads within 400 m	0.29	0.17	0.19
Development 1000 m	0.24	0.17	0.57
Water within 100 m	0.25	0.00	0.14
Water within 1000 m	0.26	0.05	0.08
Dry Wash within 100 m	0.28	0.21	0.50
Trees within 100 m	0.34	0.17	0.08
Deciduous trees	0.24	0.19	0.75
Coniferous trees	0.29	0.02	0.02
Trees within 1000 m	0.38	0.18	0.07
Riparian Shrub within 100 m	0.24	0.15	0.51
Grazing within 100 m	0.27	0.00	0.04
Tall cholla within 100 m	0.26	0.12	0.20
Mistletoe within 100 m	0.12	0.54	0.00
From plant species lists (all within 100 m):			
Joshua Tree	0.31	0.04	0.01
Mojave Yucca	0.20	0.31	0.28
Acacia	0.13	0.51	0.00
Mesquite	0.21	0.46	0.11
Pinyon Pine	0.27	0.01	0.04
Juniper	0.28	0.01	0.03
Willow	0.24	0.00	0.40
Tamarisk	0.25	0.07	0.26
Creosote	0.01	0.38	0.00
Saltbush	0.22	0.28	0.65
Cliffrose	0.25	0.02	0.13
Sagebrush	0.27	0.01	0.05
Cottonwood	0.23	0.00	0.51

In logistic regressions comparing plots with Le Conte's Thrashers present to plots where they were absent, we found that Le Conte's Thrasher sites were significantly lower in elevation (mean elevation of Le Conte's Thrasher plots = 2,878 ft), had no plants above 10 m height, and they had a higher proportion of mesquite, acacia, creosote, and saltbush, but no tamarisk compared with sites where no Le Conte's Thrashers were detected (Table 26).

Table 26. Logistic regression results for habitat models predicting Le Conte's Thrasher occurrence (detected on 26 points), with mean and standard error of the variables at points with or without detections the species. All variables except elevation are derived from point-centered-quarter plotless sampling.

	Species not detected	Species detected	coefficient	p-value	R^2
Elevation in feet	3,443 ±41	2,878 ±95	-	0.04	0.01
Plant Density at 0 to 0.5 m height	4,306 ±186	1,143 ±1,963	-	0.53	0.00
Plant Density at 0.5 to 1.5 m height	1,131 ±41	1,113 ±371		0.95	0.00
Plant Density at 1.5 to 4 m height	192 ±11.5	138 ±26	-	0.47	0.00
Plant Density at 4 to 10 m height	14.5 ±1.6	0.74 ±4.2	-	0.12	0.00
Plant Density at > 10 m height	5.1 ±2.8	0.00	-	0.00	0.01
Joshua Tree (proportion of density)	0.053 ±0.003	0.018 ±0.011	-	0.06	0.02
Mojave Yucca (proportion of density)	0.031 ±0.002	0.004 ±0.004	-	0.90	0.00
Acacia (proportion of density)	0.033 ±0.002	0.065 ±0.019	+	0.02	0.01
Mesquite (proportion of density)	0.012 ±0.001	0.066 ±0.020	+	0.00	0.03
Tamarisk (proportion of density)	0.039 ±0.004	0.00	-	0.00	0.02
Creosote (proportion of density)	0.191 ±0.005	0.308 ±0.037	+	0.00	0.03
Saltbush (proportion of density)	0.032 ±0.003	0.081 ±0.028	+	0.02	0.01
Blackbrush (proportion of density)	0.036 ±0.002	0.011 ±0.006	-	0.14	0.01
Pinyon Pine (proportion of density)	0.045 ±0.003	0.008 ±0.008	-	0.08	0.02
Juniper (proportion of density)	0.024 ±0.001	0.004 ±0.004	-	0.08	0.02

Observed Actual Distribution

The Le Conte's Thrasher distribution based on our survey records shows a widespread use of mid to low elevation upland desert areas of Clark County (Figure 38). The species is more common than the Bendire's Thrasher but has overall a similar distribution pattern that shows a dispersed use of the overall landscape, which makes conservation planning for these populations more difficult than if it were concentrated around hotspots. However, the encouraging side of this pattern is that large opportunities for management of this species still exist.

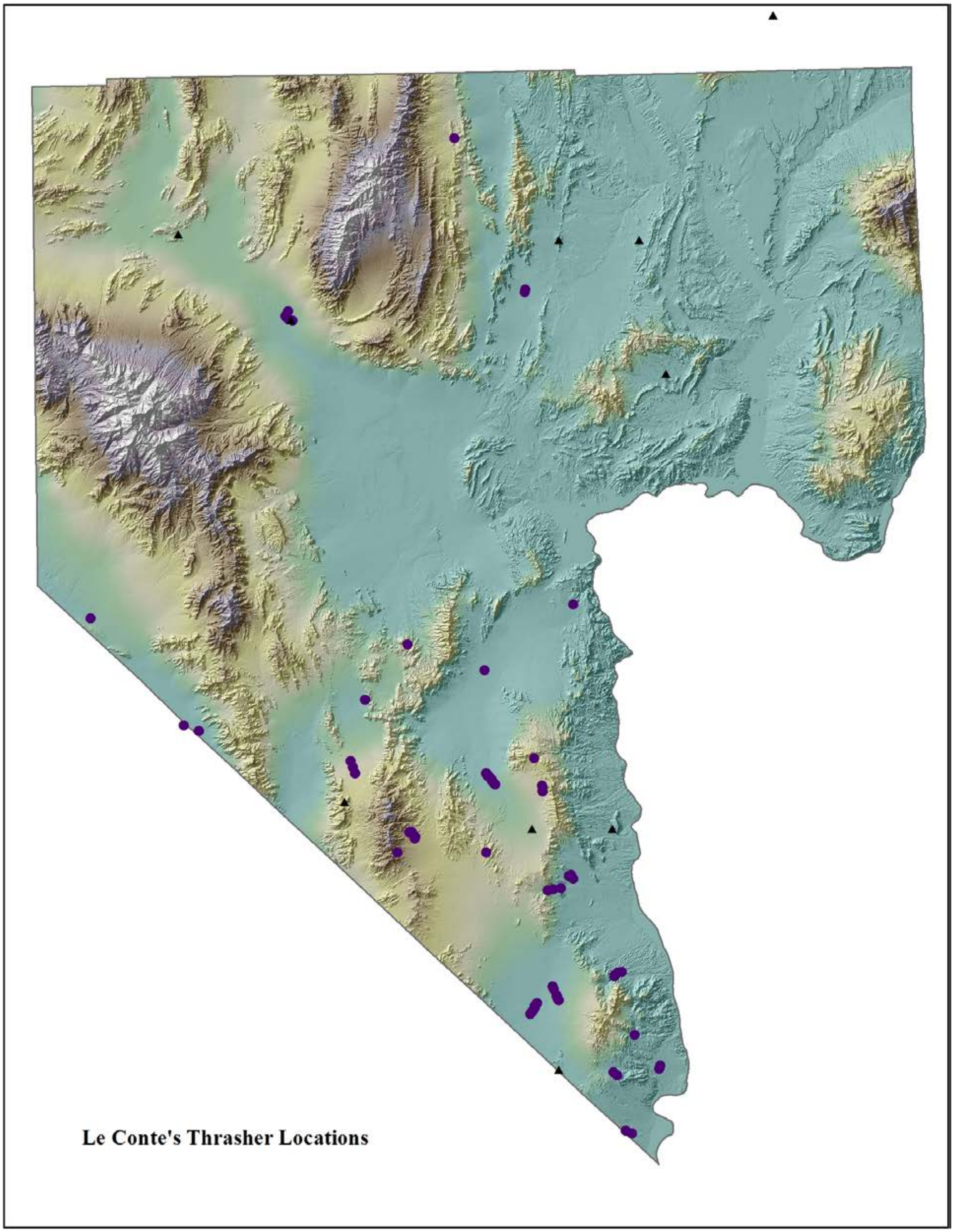

Figure 38. Le Conte's Thrasher locations within Clark County. Circles indicate records at Nevada Bird Count transect points (2003-2013); triangles indicate Breeding Bird Atlas records (1998-2000).

Spatial Habitat Models

As observed in the actual distribution records, the predicted distribution of Le Conte's Thrasher is broad and reaches most areas in Clark County and the greater region (Figure 39 and 40). Generally, only riparian areas, montane habitats, and the urban areas are predicted to have no birds, whereas most other areas are potential habitat for the species, if appropriate habitats are present.

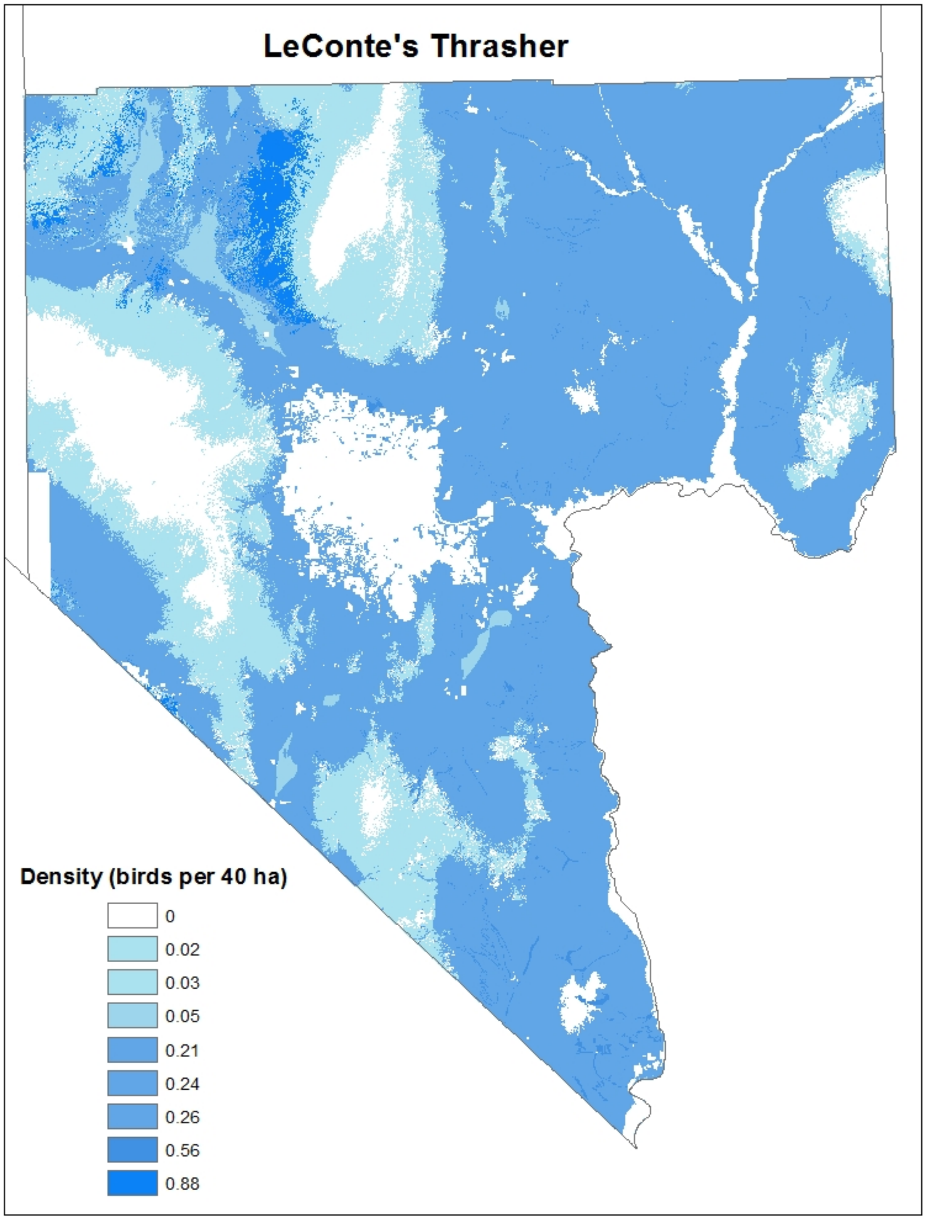

Figure 39. Predicted distribution of Le Conte's Thrashers in Clark County. Mapped values represent the predicted density of the Le Conte's Thrasher in each GIS habitat category from the Clark County habitat map (Heaton et al. 2011).

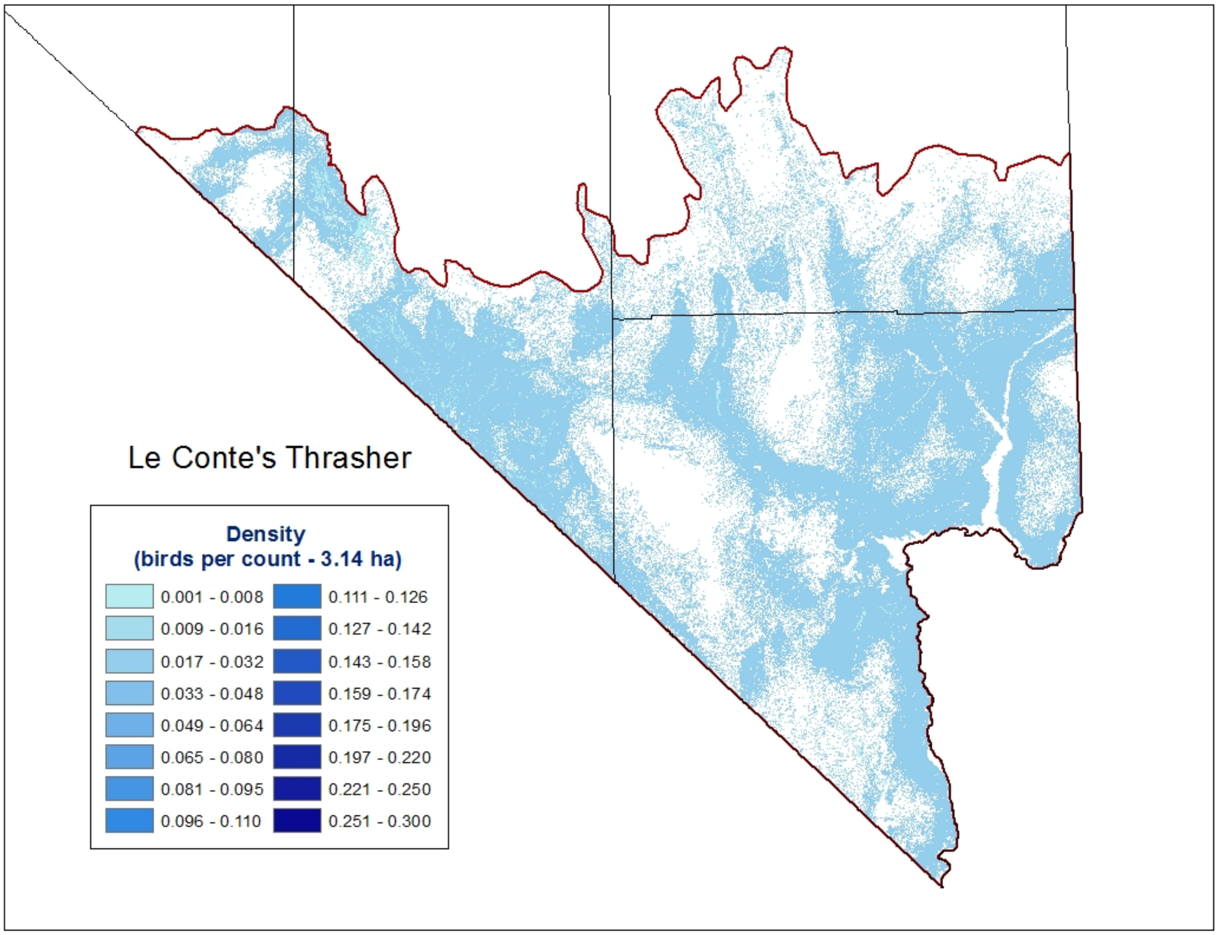

Figure 40. Predicted distribution of Le Conte's Thrasher in Clark County and the surrounding Mojave Desert. Mapped values are derived from the mean abundance per point count in habitat categories according to Provencher and Anderson (2011).

Conclusions and Recommendations

Clark County took an early and important lead in geographically broad-scale landbird monitoring in Nevada, originally through funding the Breeding Bird Atlas project (Floyd et al. 2007), and later through significant contributions to the Nevada Bird Count (NBC), the first comprehensive landbird monitoring program in the state. The project presented in this report describes the past six years of NBC implementation with special emphasis on nine focal species of the Clark County MSHCP. Together, these efforts helped significantly in our better understanding of the distribution, landscape use, population sizes, and relative densities in Clark County habitat types of many landbirds and the nine focal species, in particular.

Birds of Clark County and Population Size Estimates

A total of 229 species were recorded in Clark County during our NBC surveys, which represents about 75% of the number of species that regularly occur in Nevada and about 48% of the number of species that have ever been reported in the state (GBBO 2010). The large bird species diversity of Clark County can be ascribed to the large degree of environmental variation in terms of different habitat types and elevational zones available. For the MSHCP covered species, it is clear that Clark County's riparian resources represent the critical support system for maintaining their populations.

For all population size estimates reported here, we emphasize the methodological difficulty of estimating populations of rare species even with a geographically far-reaching and randomized sampling scheme, as we used in Clark County. Uncommon and rare species are notorious for having fluctuating populations and shifting breeding territory locations among years. The issue is further complicated, if the species have unpredictable detectability patterns and poorly defined territory boundaries, and the most important examples for this are Bendire's and Le Conte's thrashers. Therefore, we urge the reader to pay close attention to the 95% confidence intervals reported with the population estimates, and if these are wide, to note that the true population size estimate for that year or stratum remains unknown. Population size estimates from samples, such as ours, work best for species that are reasonably common, highly detectable, very territorial, and restricted to a well-defined habitat type, which is only true for very few of our focal species.

We further recommend examining the results of the two correction methods that attempt to account for detectability in the population estimates, double-sampling and removal models. As a general rule, if the two methods of calculating detectability result in similar population estimates, our confidence that the true population size is at least approximated increases. If the two methods produce wildly different results in population size, by stratum or year, our confidence in either estimate fades.

Therefore, our recommendation is to focus on density estimates, at least on those with relatively narrow confidence intervals, for future species conservation planning in Clark County. For instance, it is much easier to plan for a target density of a focal species in its preferred habitat type, for which a conservation project might be planned, than it is to plan for a target population size in the project site, which will be subject to the same methodological difficulties as described in this study, but to an even extremer degree because it will involve even smaller sampling areas.

Distributions and Habitat Use of Focal Species

The MSHCP covered species included in this study are all riparian-associated, with some more strictly riparian-obligate than others. Willow Flycatcher and Vermilion Flycatcher occurred exclusively along the rivers of Clark County and we had no evidence of breeding records of these species elsewhere in the county. In a slightly different landscape use pattern, the Summer Tanager and the Bell's Vireo occurred along these rivers, but also made significant use of small spring outflows that are scattered throughout the county and sometimes provide small, but high-quality, riparian habitat patches. This provides an important piece of information for conservation planning for these species in Clark County, in that conservation projects to benefit the two flycatchers are most likely to be successful in the river systems, which projects on spring outflows and other small riparian systems may be especially important to the tanager, but also benefit Bell's Vireo. Phainopepla and Blue Grosbeak showed a more flexible landscape use pattern because the former occurs in a wider variety of habitat types than most other covered species, and the latter is more tolerant of degraded riparian areas, which are generally more available than intact areas.

In contrast to the MSHCP covered species, the MSHCP evaluation species are desert upland specialists. The Bendire's and Le Conte's thrashers both inhabit scrubby uplands of the low to mid elevations of Clark County. These are the areas of the county where land developments and off-road vehicle recreation are most prevalent and pose the risk of fragmenting remaining intact habitat patches of these species. Unfortunately for county planning, their preferred habitats are widespread, and their distributions are somewhat unpredictable across the landscape. We suspect that areas of seemingly suitable habitat for one or both of these species may not always be occupied, but may matter to their long-term population maintenance as alternate sites. Therefore, landscape planning for these species almost necessarily needs to be broad in scope, and recommendations for minimum patch sizes for conservation projects can be reviewed in GBBO (2010). The Gray Vireo stands out as the only truly montane species among all other focal species. Therefore, its conservation planning needs affect different land management agencies, different habitat types (pinyon-juniper), and slightly different habitat threats than all other MSHCP species. Within Clark County, we see their conservation as mostly taking place in the lower montane zones of the Spring Mountains and the Sheep Range, but other remote montane areas are also of great interest for Gray Vireo conservation planning. We found them to be particularly responsive to woodland-transitional areas, which generally feature a higher shrub diversity than interior habitat areas, but these preferred areas may also be more prone to devastating fires and recreational impacts.

Recommendations for Monitoring

With the new spatial data that are available for Clark County (Heaton et al. 2011, Provencher and Anderson 2011), monitoring of birds and other wildlife has become significantly easier than at the beginning of this six-year project. Statistically sound sampling plans depend very much on the quality of spatial data that allow for spatial randomization and stratification. With the new Clark County vegetation map, our restratification was made possible, and we believe that the data collected under the new sampling scheme are more rigorous than was previously possible. With continued landbird monitoring, population sizes will become clearer, albeit not available as a rigorous *annual* population size estimate. Instead, we recommend that population sizes be estimated using blocks of several years' worth of data collected on random samples from all strata. It is also not inherently necessary that this be done on a continuous basis, but it may be done in intervals.

Recommendations for Conservation Planning

For conservation project planning and effectiveness monitoring, we recommend using habitat-specific density estimates of the focal species for setting and evaluating project objectives. We encourage all conservation partners to also include sensitive species that were not the focus of this study (these are identified in Appendix 2) in their project planning, if their project allows for a multi-species approach. Several of these species have significantly declining population trends in the Southwestern region, and some may be at risk of local extirpation if their preferred habitats are widely impacted or degraded. The urgency for conservation action for these species can be reviewed in the *Nevada Comprehensive Bird Conservation Plan* (GBBO 2010). Conservation strategies for these species and for six of our nine focal species are also available in that document. Furthermore, the *Nevada Comprehensive Bird Conservation Plan* comes with accompanying documents that lead the land manager step-by-step through the calculation of potential bird benefits of their specific, local conservation project. This *Habitat Implementation Worksheet* is available, along with the downloadable plan, at http://www.gbbo.org/bird_conservation_plan.html.

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Appendix 1. Species list of birds found within Clark County, Nevada, 2003-2013.

Common Name	**Scientific Name**
Canada Goose	*Branta canadensis*
Gadwall	*Anas strepera*
American Wigeon	*Anas americana*
Mallard	*Anas platyrhynchos*
Cinnamon Teal	*Anas cyanoptera*
Northern Shoveler	*Anas clypeata*
Northern Pintail	*Anas acuta*
Green-winged Teal	*Anas crecca*
Redhead	*Aythya americana*
Ring-necked Duck	*Aythya collaris*
Lesser Scaup	*Aythya affinis*
Bufflehead	*Bucephala albeola*
Common Goldeneye	*Bucephala clangula*
Ruddy Duck	*Oxyura jamaicensis*
Chukar	*Alectoris chukar*
Ring-necked Pheasant	*Phasianus colchicus*
Dusky Grouse	*Dendragapus obscurus*
Wild Turkey	*Meleagris gallopavo*
Gambel's Quail	*Callipepla gambelii*
Pied-billed Grebe	*Podilymbus podiceps*
Eared Grebe	*Podiceps nigricollis*
Western Grebe	*Aechmophorus occidentalis*
Clark's Grebe	*Aechmophorus clarkii*
Double-crested Cormorant	*Phalacrocorax auritus*
American White Pelican	*Pelecanus erythrorhynchos*
American Bittern	*Botaurus lentiginosus*
Least Bittern	*Ixobrychus exilis*
Great Blue Heron	*Ardea herodias*
Great Egret	*Ardea alba*
Snowy Egret	*Egretta thula*
Green Heron	*Butorides virescens*
Black-crowned Night-Heron	*Nycticorax nycticorax*
White-faced Ibis	*Plegadis chihi*
Turkey Vulture	*Cathartes aura*
Osprey	*Pandion haliaetus*
Northern Harrier	*Circus cyaneus*
Sharp-shinned Hawk	*Accipiter striatus*

Common Name	Scientific Name
Cooper's Hawk	*Accipiter cooperii*
Northern Goshawk	*Accipiter gentilis*
Swainson's Hawk	*Buteo swainsoni*
Zone-tailed Hawk	*Buteo albonotatus*
Red-tailed Hawk	*Buteo jamaicensis*
Golden Eagle	*Aquila chrysaetos*
Virginia Rail	*Rallus limicola*
Sora	*Porzana carolina*
American Coot	*Fulica americana*
Black-necked Stilt	*Himantopus mexicanus*
American Avocet	*Recurvirostra americana*
Snowy Plover	*Charadrius nivosus*
Killdeer	*Charadrius vociferus*
Spotted Sandpiper	*Actitis macularius*
Greater Yellowlegs	*Tringa melanoleuca*
Lesser Yellowlegs	*Tringa flavipes*
Least Sandpiper	*Calidris minutilla*
Long-billed Dowitcher	*Limnodromus scolopaceus*
Wilson's Snipe	*Gallinago delicata*
Wilson's Phalarope	*Phalaropus tricolor*
Franklin's Gull	*Leucophaeus pipixcan*
Ring-billed Gull	*Larus delawarensis*
California Gull	*Larus californicus*
Forster's Tern	*Sterna forsteri*
Rock Pigeon	*Columba livia*
Band-tailed Pigeon	*Patagioenas fasciata*
Eurasian Collared-Dove	*Streptopelia decaocto*
White-winged Dove	*Zenaida asiatica*
Mourning Dove	*Zenaida macroura*
Greater Roadrunner	*Geococcyx californianus*
Barn Owl	*Tyto alba*
Flammulated Owl	*Psiloscops flammeolus*
Western Screech-Owl	*Megascops kennicottii*
Great Horned Owl	*Bubo virginianus*
Burrowing Owl	*Athene cunicularia*
Long-eared Owl	*Asio otus*
Short-eared Owl	*Asio flammeus*
Lesser Nighthawk	*Chordeiles acutipennis*

Common Name	Scientific Name
Common Nighthawk	*Chordeiles minor*
Common Poorwill	*Phalaenoptilus nuttallii*
Vaux's Swift	*Chaetura vauxi*
White-throated Swift	*Aeronautes saxatalis*
Black-chinned Hummingbird	*Archilochus alexandri*
Anna's Hummingbird	*Calypte anna*
Costa's Hummingbird	*Calypte costae*
Broad-tailed Hummingbird	*Selasphorus platycercus*
Rufous Hummingbird	*Selasphorus rufus*
Calliope Hummingbird	*Selasphorus calliope*
Belted Kingfisher	*Megaceryle alcyon*
Lewis's Woodpecker	*Melanerpes lewis*
Red-headed Woodpecker	*Melanerpes erythrocephalus*
Red-naped Sapsucker	*Sphyrapicus nuchalis*
Ladder-backed Woodpecker	*Picoides scalaris*
Downy Woodpecker	*Picoides pubescens*
Hairy Woodpecker	*Picoides villosus*
Northern Flicker	*Colaptes auratus*
Gilded Flicker	*Colaptes chrysoides*
American Kestrel	*Falco sparverius*
Merlin	*Falco columbarius*
Peregrine Falcon	*Falco peregrinus*
Prairie Falcon	*Falco mexicanus*
Olive-sided Flycatcher	*Contopus cooperi*
Western Wood-Pewee	*Contopus sordidulus*
Willow Flycatcher	*Empidonax traillii*
Hammond's Flycatcher	*Empidonax hammondii*
Gray Flycatcher	*Empidonax wrightii*
Dusky Flycatcher	*Empidonax oberholseri*
Cordilleran Flycatcher	*Empidonax occidentalis*
Black Phoebe	*Sayornis nigricans*
Say's Phoebe	*Sayornis saya*
Vermilion Flycatcher	*Pyrocephalus rubinus*
Ash-throated Flycatcher	*Myiarchus cinerascens*
Brown-crested Flycatcher	*Myiarchus tyrannulus*
Cassin's Kingbird	*Tyrannus vociferans*
Western Kingbird	*Tyrannus verticalis*
Loggerhead Shrike	*Lanius ludovicianus*

Common Name	Scientific Name
Bell's Vireo	*Vireo bellii*
Gray Vireo	*Vireo vicinior*
Plumbeous Vireo	*Vireo plumbeus*
Cassin's Vireo	*Vireo cassinii*
Warbling Vireo	*Vireo gilvus*
Steller's Jay	*Cyanocitta stelleri*
Western Scrub-Jay	*Aphelocoma californica*
Pinyon Jay	*Gymnorhinus cyanocephalus*
Clark's Nutcracker	*Nucifraga columbiana*
Black-billed Magpie	*Pica hudsonia*
American Crow	*Corvus brachyrhynchos*
Common Raven	*Corvus corax*
Horned Lark	*Eremophila alpestris*
Tree Swallow	*Tachycineta bicolor*
Violet-green Swallow	*Tachycineta thalassina*
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*
Bank Swallow	*Riparia riparia*
Cliff Swallow	*Petrochelidon pyrrhonota*
Barn Swallow	*Hirundo rustica*
Black-capped Chickadee	*Poecile atricapillus*
Mountain Chickadee	*Poecile gambeli*
Juniper Titmouse	*Baelophus ridgwayi*
Verdin	*Auriparus flaviceps*
Bushtit	*Psaltriparus minimus*
Red-breasted Nuthatch	*Sitta canadensis*
White-breasted Nuthatch	*Sitta carolinensis*
Pygmy Nuthatch	*Sitta pygmaea*
Brown Creeper	*Certhia americana*
Rock Wren	*Salpinctes obsoletus*
Canyon Wren	*Catherpes mexicanus*
House Wren	*Troglodytes aedon*
Marsh Wren	*Cistothorus palustris*
Bewick's Wren	*Thryomanes bewickii*
Cactus Wren	*Campylorhynchus brunneicapillus*
Blue-gray Gnatcatcher	*Polioptila caerulea*
Black-tailed Gnatcatcher	*Polioptila melanura*
Golden-crowned Kinglet	*Regulus satrapa*
Ruby-crowned Kinglet	*Regulus calendula*

Common Name	Scientific Name
Western Bluebird	*Sialia mexicana*
Mountain Bluebird	*Sialia currucoides*
Townsend's Solitaire	*Myadestes townsendi*
Veery	*Catharus fuscescens*
Swainson's Thrush	*Catharus ustulatus*
Hermit Thrush	*Catharus guttatus*
American Robin	*Turdus migratorius*
Bendire's Thrasher	*Toxostoma bedirei*
Le Conte's Thrasher	*Toxostoma lecontei*
Crissal Thrasher	*Toxostoma crissale*
Sage Thrasher	*Oreoscoptes montanus*
Northern Mockingbird	*Mimus polyglottos*
European Starling	*Sturnus vulgaris*
American Pipit	*Anthus rubescens*
Cedar Waxwing	*Bombycilla cedrorum*
Phainopepla	*Phainopepla nitens*
Black-and-white Warbler	*Mniotilta varia*
Orange-crowned Warbler	*Oreothlypis celata*
Lucy's Warbler	*Oreothlypis luciae*
Nashville Warbler	*Oreothlypis ruficapilla*
Virginia's Warbler	*Oreothlypis virginiae*
MacGillivray's Warbler	*Geothlypis tolmiei*
Common Yellowthroat	*Geothlypis trichas*
American Redstart	*Setophaga ruticilla*
Yellow Warbler	*Setophaga petechia*
Yellow-rumped Warbler	*Setophaga coronata*
Grace's Warbler	*Setophaga graciae*
Black-throated Gray Warbler	*Setophaga nigrescens*
Townsend's Warbler	*Setophaga townsendi*
Hermit Warbler	*Setophaga occidentalis*
Wilson's Warbler	*Cardellina pusilla*
Yellow-breasted Chat	*Icteria virens*
Green-tailed Towhee	*Pipilo chlorurus*
Spotted Towhee	*Pipilo maculatus*
Rufous-crowned Sparrow	*Aimophila ruficeps*
Abert's Towhee	*Melozone aberti*
Chipping Sparrow	*Spizella passerina*
Brewer's Sparrow	*Spizella breweri*

Common Name	**Scientific Name**
Black-chinned Sparrow	*Spizella atrogularis*
Vesper Sparrow	*Pooecetes gramineus*
Lark Sparrow	*Chondestes grammacus*
Black-throated Sparrow	*Amphispiza bilineata*
Sagebrush Sparrow	*Artemisiospiza nevadensis*
Bell's Sparrow	*Artemisiospiza belli*
Lark Bunting	*Calamospiza melanocorys*
Savannah Sparrow	*Passerculus sandwichensis*
Song Sparrow	*Melospiza melodia*
Lincoln's Sparrow	*Melospiza lincolnii*
White-crowned Sparrow	*Zonotrichia leucophrys*
Golden-crowned Sparrow	*Zonotrichia atricapilla*
Dark-eyed Junco	*Junco hyemalis*
Hepatic Tanager	*Piranga flava*
Summer Tanager	*Piranga rubra*
Western Tanager	*Piranga ludoviciana*
Rose-breasted Grosbeak	*Pheucticus ludovicianus*
Black-headed Grosbeak	*Pheucticus melanocephalus*
Blue Grosbeak	*Passerina caerulea*
Lazuli Bunting	*Passerina amoena*
Indigo Bunting	*Passerina cyanea*
Red-winged Blackbird	*Agelaius phoeniceus*
Western Meadowlark	*Sturnella neglecta*
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*
Brewer's Blackbird	*Euphagus cyanocephalus*
Common Grackle	*Quiscalus quiscula*
Great-tailed Grackle	*Quiscalus mexicanus*
Brown-headed Cowbird	*Molothrus ater*
Bullock's Oriole	*Icterus bullockii*
Scott's Oriole	*Icterus parisorum*
Hooded Oriole	*Icterus cucullatus*
Pine Grosbeak	*Pinicola enucleator*
House Finch	*Haemorhous mexicanus*
Cassin's Finch	*Haemorhous cassinii*
Red Crossbill	*Loxia curvirostra*
Pine Siskin	*Spinus pinus*
Lesser Goldfinch	*Spinus psaltria*
Lawrence's Goldfinch	*Spinus lawrencei*

Common Name	**Scientific Name**
American Goldfinch	*Spinus tristis*
House Sparrow	*Passer domesticus*

Appendix 2. Average estimated densities of all species detected during point count surveys on 316 transects within 12 habitat types in Clark County, Nevada, 2003-2013. Estimated densities are reported for actual habitat type observed at each transect, in mean # bird detections per 40 hectares. Light green shading indicates conservation priority species according to GBBO (2010). Bold type indicates focal bird species of the Clark County MSHCP. Incidental records and flyovers are denoted by an "X".

Species	**Agriculture** (n = 33 surveys)	**Aspen** (n = 10 surveys)	**Coniferous Forest** (n = 49 surveys)	**Joshua Tree** (n = 221 surveys)	**Lowland Riparian** (n = 211 surveys)	**Mesquite-Catclaw** (n = 116 surveys)	**Mojave Scrub** (n = 147 surveys)	**Montane Riparian** (n = 49 surveys)	**Montane Sagebrush** (n = 8 surveys)	**Montane Shrublands** (n = 39 surveys)	**Pinyon-Juniper** (n = 116 surveys)	**Salt Desert** (n = 68 surveys)	**Number of Habitats Used**
Canada Goose	1.59				0.09								**2**
Gadwall	X				0.01								**2**
American Wigeon					X								**1**
Mallard	3.62				0.49	0.02							**3**
Cinnamon Teal	0.49				0.07								**2**
Northern Shoveler	0.12				0.07								**2**
Northern Pintail	X												**1**
Green-winged Teal	X				0.01								**2**
Redhead					0.05								**1**
Ring-necked Duck	X				X								**2**
Lesser Scaup					0.02								**1**
Bufflehead					0.01								**1**
Common Goldeneye					0.01								**1**
Ruddy Duck					0.09								**1**
Gambel's Quail	9.64		X	1.39	10.75	5.84	1.85	0.16	1.27	1.83	0.54	0.96	**11**
Chukar			0.08	0.3	0.06	0.01	X	0.85		0.26	0.18		**8**
Ring-necked Pheasant	0.2				0.14								**2**
Dusky Grouse											0.01		**1**
Wild Turkey	0.33				0.02								**2**

Species	Agriculture (n = 33 surveys)	Aspen (n = 10 surveys)	Coniferous Forest (n = 49 surveys)	Joshua Tree (n = 221 surveys)	Lowland Riparian (n = 211 surveys)	Mesquite-Catclaw (n = 116 surveys)	Mojave Scrub (n = 147 surveys)	Montane Riparian (n = 49 surveys)	Montane Sagebrush (n = 8 surveys)	Montane Shrublands (n = 39 surveys)	Pinyon-Juniper (n = 116 surveys)	Salt Desert (n = 68 surveys)	Number of Habitats Used
Guinea Fowl	0.04				X		X						**3**
Pied-billed Grebe	X				0.09		X						**3**
Eared Grebe					0.06	X							**2**
Western Grebe					0.01								**1**
Clark's Grebe					X								**1**
American White Pelican	X				X								**2**
Double-crested Cormorant	X				0.01		X						**3**
American Bittern					X								**1**
Least Bittern					0.01								**1**
Great Blue Heron	0.73				0.05								**2**
Great Egret	0.24				0.03								**2**
Snowy Egret	0.04				0.03								**2**
Green Heron	X				0.04								**2**
Black-crowned Night-Heron	0.04				0.03								**2**
White-faced Ibis	X				0.17								**2**
Turkey Vulture	1.42			0.03	0.55	0.01	0.02			0.03	0.02	X	**8**
Osprey					X	X	X						**3**
Northern Harrier	0.04			X	X	X	X					X	**6**
Sharp-shinned Hawk	X		0.03	X	0.01		0.02	0.03		0.07			**7**
Cooper's Hawk	0.04		0.14	0.01	0.04		0.01	0.03		X	0.01		**8**
Northern Goshawk			0.03										**1**

Species	Agriculture (n = 33 surveys)	Aspen (n = 10 surveys)	Coniferous Forest (n = 49 surveys)	Joshua Tree (n = 221 surveys)	Lowland Riparian (n = 211 surveys)	Mesquite-Catclaw (n = 116 surveys)	Mojave Scrub (n = 147 surveys)	Montane Riparian (n = 49 surveys)	Montane Sagebrush (n = 8 surveys)	Montane Shrublands (n = 39 surveys)	Pinyon-Juniper (n = 116 surveys)	Salt Desert (n = 68 surveys)	Number of Habitats Used
Swainson's Hawk				X	X		X	0.03			0.01		**5**
Zone-tailed Hawk					X	X					X		**3**
Red-tailed Hawk	0.16	X		0.08	0.11	0.1	0.03	X		0.2	0.03	0.02	**10**
Golden Eagle			X		X	X	X	X	X		X		**7**
American Kestrel	0.08		X	0.01	0.07	0.02	0.03			X	0.03		**8**
Merlin						X							**1**
Peregrine Falcon	X		X	0.01	0.03	X							**5**
Prairie Falcon				X	0.01	X	X					X	**5**
Virginia Rail	0.08				0.26								**2**
Sora					0.02								**1**
American Coot	0.04				0.81								**2**
Snowy Plover					X								**1**
Killdeer	0.45				0.38		X					0.19	**4**
Black-necked Stilt	0.12				0.01								**2**
American Avocet	0.16				0.02								**2**
Spotted Sandpiper	0.08				0.09								**2**
Greater Yellowlegs	0.16				0.01								**2**
Lesser Yellowlegs	0.12												**1**
Least Sandpiper					0.01								**1**
Long-billed Dowitcher	0.81				0.11								**2**
Wilson's Snipe					0.01								**1**
Wilson's Phalarope	0.24				0.01								**2**
Franklin's Gull					X								**1**

Species	Agriculture (n = 33 surveys)	Aspen (n = 10 surveys)	Coniferous Forest (n = 49 surveys)	Joshua Tree (n = 221 surveys)	Lowland Riparian (n = 211 surveys)	Mesquite-Catclaw (n = 116 surveys)	Mojave Scrub (n = 147 surveys)	Montane Riparian (n = 49 surveys)	Montane Sagebrush (n = 8 surveys)	Montane Shrublands (n = 39 surveys)	Pinyon-Juniper (n = 116 surveys)	Salt Desert (n = 68 surveys)	Number of Habitats Used
Ring-billed Gull	X				X								**2**
California Gull					X								**1**
Forster's Tern					X								**1**
Rock Pigeon	1.26				0.01	X	0.01					0.06	**5**
Band-tailed Pigeon		0.15	0.06		0.01								**3**
Eurasian Collared-Dove	4.72			0.01	0.51	0.06	0.01			X	0.03	0.04	**8**
White-winged Dove	0.12			0.01	0.46	0.01							**4**
Mourning Dove	12.28	0.29	0.78	1.47	6.36	2.87	1.35	0.95	0.95	2.71	1.61	0.9	**12**
Greater Roadrunner	0.37			0.04	0.4	0.2	0.05			0.03	0.02	0.06	**8**
Barn Owl					X		X						**2**
Flammulated Owl		0.29											**1**
Western Screech-Owl			X								X		**2**
Great Horned Owl			X	0.04	0.03	0.01	X			0.03	X		**7**
Burrowing Owl				X	X		0.03					0.02	**4**
Long-eared Owl					X								**1**
Short-eared Owl	X												**1**
Lesser Nighthawk	X			0.01	0.11	0.04	0.08				X	0.06	**7**
Common Nighthawk			0.03	X	0.01	X	0.02	0.03				0.02	**7**
Common Poorwill			0.03	0.02	0.01	X	0.01	X		0.13	0.01		**8**
Vaux's Swift				X	X	X							**3**
White-throated Swift	0.12	0.15	0.17	0.01	0.2	0.04	0.11	X		0.13	0.16	X	**11**
Black-chinned Hummingbird	0.12		0.17	0.1	0.47	0.19	0.07	0.05		0.03	0.09		**9**

Species	**Agriculture** (n = 33 surveys)	**Aspen** (n = 10 surveys)	**Coniferous Forest** (n = 49 surveys)	**Joshua Tree** (n = 221 surveys)	**Lowland Riparian** (n = 211 surveys)	**Mesquite-Catclaw** (n = 116 surveys)	**Mojave Scrub** (n = 147 surveys)	**Montane Riparian** (n = 49 surveys)	**Montane Sagebrush** (n = 8 surveys)	**Montane Shrublands** (n = 39 surveys)	**Pinyon-Juniper** (n = 116 surveys)	**Salt Desert** (n = 68 surveys)	**Number of Habitats Used**
Anna's Hummingbird	0.04		0.03	0.01	0.09	0.01	0.02	0.32		0.2	0.14		**9**
Costa's Hummingbird		X	0.03	0.18	0.25	0.3	0.15	0.08	0.16	X	0.06		**10**
Calliope Hummingbird					0.01			0.03			0.01		**3**
Broad-tailed Hummingbird		11.56	5.61	0.05	0.13		0.02	4.24		1.04	0.91	0.02	**9**
Rufous Hummingbird						0.02		0.03					**2**
Belted Kingfisher					0.03								**1**
Lewis's Woodpecker					0.01								**1**
Red-headed Woodpecker		0.15						0.03					**2**
Red-naped Sapsucker			0.17					0.05					**2**
Ladder-backed Woodpecker	0.04			0.82	0.53	0.12	0.04		0.16	0.13	0.13	X	**9**
Downy Woodpecker											X		**1**
Hairy Woodpecker		2.2	1.56	0.01	0.01			0.37		0.2	0.08		**7**
Northern Flicker	X	1.61	3.18	0.11	0.03		0.01	1.78		0.29	0.15	0.02	**10**
Gilded Flicker				0.04		X							**2**
Olive-sided Flycatcher		0.15	0.22	0.01	0.04	0.03				0.03	0.03		**7**
Western Wood-Pewee	0.08	0.29	1.48	0.11	0.43	0.11	0.04	0.42		0.39	0.28	0.06	**11**
Willow Flycatcher					**0.07**								**1**
Hammond's Flycatcher		0.29	0.28	0.01	0.01			0.08			0.01		**6**
Gray Flycatcher			1.01	0.19	0.15	0.2	0.07	2.94	0.16	1.4	1.23	0.04	**10**

Species	**Agriculture** (n = 33 surveys)	**Aspen** (n = 10 surveys)	**Coniferous Forest** (n = 49 surveys)	**Joshua Tree** (n = 221 surveys)	**Lowland Riparian** (n = 211 surveys)	**Mesquite-Catclaw** (n = 116 surveys)	**Mojave Scrub** (n = 147 surveys)	**Montane Riparian** (n = 49 surveys)	**Montane Sagebrush** (n = 8 surveys)	**Montane Shrublands** (n = 39 surveys)	**Pinyon-Juniper** (n = 116 surveys)	**Salt Desert** (n = 68 surveys)	**Number of Habitats Used**
Dusky Flycatcher		8.05	5.5	0.01	0.09	0.13	0.02	2.55		0.33	0.53	0.11	**10**
"Western" Flycatcher			0.06	0.05	0.04	0.02	0.02	0.05			0.07		**7**
Cordilleran Flycatcher		0.29	0.22		0.01			0.34			0.05		**5**
Black Phoebe	0.2				0.45	0.01							**3**
Say's Phoebe	1.75			0.44	0.83	0.5	0.58	0.05			0.1	0.19	**8**
Vermilion Flycatcher	**0.53**				**0.6**	X							**3**
Ash-throated Flycatcher	0.57		0.28	5.56	2.13	3.93	2.31	3.42	5.89	3.75	3.02	2.07	**11**
Brown-crested Flycatcher					0.15	0.02							**2**
Cassin's Kingbird					0.02						0.06		**2**
Western Kingbird	3.99			0.11	1	0.28	0.01		0.16	0.1	0.03	0.11	**9**
Loggerhead Shrike	0.12			1.32	0.21	1.28	1.1		0.64	0.16	0.13	0.38	**9**
Bell's Vireo	**0.41**			**0.01**	**1.43**	**0.09**		**0.05**			**0.01**		**6**
Gray Vireo			**1.01**	**0.08**	**0.06**	**0.02**	**0.02**	**2.65**		**1.18**	**2.56**	**0.02**	**9**
Plumbeous Vireo			0.81		0.01			0.42		0.03	0.15		**5**
"Solitary" Vireo				0.01									**1**
Cassin's Vireo			0.03	0.02	0.04						0.09		**4**
Warbling Vireo		13.9	2.35	0.03	0.16	0.07		0.34		0.16	0.13		**8**
Pinyon Jay			0.14	1.67	0.04		X	0.95		0.65	2.18	X	**8**
Steller's Jay		3.81	0.59	0.01				0.03			0.01		**5**
Western Scrub-Jay	0.04	0.29	0.89	0.11	0.59	0.01		6.26		4.64	3.07		**9**
Clark's Nutcracker		0.44	0.7					0.03			0.01		**4**
Black-billed Magpie	0.04							X					**2**

Species	Agriculture (n = 33 surveys)	Aspen (n = 10 surveys)	Coniferous Forest (n = 49 surveys)	Joshua Tree (n = 221 surveys)	Lowland Riparian (n = 211 surveys)	Mesquite-Catclaw (n = 116 surveys)	Mojave Scrub (n = 147 surveys)	Montane Riparian (n = 49 surveys)	Montane Sagebrush (n = 8 surveys)	Montane Shrublands (n = 39 surveys)	Pinyon-Juniper (n = 116 surveys)	Salt Desert (n = 68 surveys)	Number of Habitats Used
American Crow					X								**1**
Common Raven	0.94	1.46	0.39	0.08	0.21	0.08	0.34	0.16	X	0.1	0.06	0.13	**12**
Horned Lark	1.26			0.35	0.17	0.78	2.34		0.32	0.1	X	10.38	**9**
Tree Swallow	0.73				0.54	X	X						**4**
Violet-green Swallow	3.54	1.02	2.32	0.01	0.63	0.02	0.03	1.01		0.03	0.07	0.02	**11**
Northern Rough-winged Swallow	6.06			0.01	1.6	0.04	0.02	X			0.08	X	**8**
Bank Swallow				0.01	0.01								**2**
Cliff Swallow	5.78			X	2.41	X	0.06						**5**
Barn Swallow	0.57			X	0.02	X	X				X	X	**7**
Black-capped Chickadee								0.05					**1**
Mountain Chickadee		3.66	8.8		0.01			2.76		0.52	0.59		**6**
Juniper Titmouse			0.03	0.06	0.06		0.03	3.08		1.63	2.33		**7**
Verdin	2.4			0.37	4.48	4.63	0.35			X		0.34	**7**
Bushtit		0.15	0.17	0.06	0.32	0.19	0.01	4.75		4.86	2.34	0.02	**10**
Red-breasted Nuthatch	X	0.29	0.92	X	0.01			X		X	0.03		**8**
White-breasted Nuthatch		0.44	1.76					0.9			0.16		**4**
Pygmy Nuthatch		0.73	3.77					0.95		0.03	0.01		**5**
Brown Creeper		0.15	0.56					0.16		0.07			**4**
Cactus Wren				3.51	0.47	2.14	1.54	0.03	3.18	1.31	0.25	2.01	**9**
Rock Wren	0.08		0.03	0.95	0.29	0.53	2.4	0.19	0.16	0.85	1.16	0.68	**11**
Canyon Wren		0.15	0.06	0.02	0.19	0.01	0.07	X	x	0.07	0.18		**10**

Species	**Agriculture** (n = 33 surveys)	**Aspen** (n = 10 surveys)	**Coniferous Forest** (n = 49 surveys)	**Joshua Tree** (n = 221 surveys)	**Lowland Riparian** (n = 211 surveys)	**Mesquite-Catclaw** (n = 116 surveys)	**Mojave Scrub** (n = 147 surveys)	**Montane Riparian** (n = 49 surveys)	**Montane Sagebrush** (n = 8 surveys)	**Montane Shrublands** (n = 39 surveys)	**Pinyon-Juniper** (n = 116 surveys)	**Salt Desert** (n = 68 surveys)	**Number of Habitats Used**
Bewick's Wren	1.79	0.15	0.61	1.19	2.78	0.69	0.06	2.25	0.16	1.86	1.98	0.04	**12**
House Wren		1.17	0.03	0.01	0.01		0.04			0.07	0.03		**7**
Marsh Wren	0.41				0.34								**2**
Blue-gray Gnatcatcher	0.24		1.01	0.87	1.01	0.91	0.11	5.52	X	4.37	5.43	0.08	**11**
Black-tailed Gnatcatcher	0.85		0.03	0.63	1.79	3.27	0.85	0.05		0.13	0.24	0.26	**10**
Golden-crowned Kinglet		0.29	0.06					0.11			0.01		**4**
Ruby-crowned Kinglet	0.08	4.39	5.31	0.08	0.14	0.03	0.02	0.21		0.13	0.44	0.02	**11**
Western Bluebird		0.15	1.56	X				0.64		0.16	0.13		**6**
Mountain Bluebird		0.15	0.08	0.03			X	X		0.16	0.03		**7**
Townsend's Solitaire			1.28	X	0.01	0.01	0.01	0.32		0.07	0.06		**8**
Veery								0.19					**1**
Swainson's Thrush			0.03								X		**2**
Hermit Thrush		12.73	4.33	X	0.01			1.51		0.03	0.09		**7**
American Robin	0.53	2.63	1.4		0.23			0.9		0.29	0.3		**7**
Northern Mockingbird	2.97			1.08	1.22	1.28	0.49	0.08	1.91	0.56	0.36	0.15	**10**
Sage Thrasher				X		X						0.06	**3**
Bendire's Thrasher				**0.04**	**0.01**	**0.01**	**0.04**					X	**5**
Crissal Thrasher	0.28			0.22	1.11	0.46	0.06	0.11		0.26	0.15	0.11	**9**
Le Conte's Thrasher				**0.1**	**0.02**	**0.97**	**0.37**			**0.03**		**0.36**	**6**
European Starling	2.4				0.48	X							**3**

Species	**Agriculture** (n = 33 surveys)	**Aspen** (n = 10 surveys)	**Coniferous Forest** (n = 49 surveys)	**Joshua Tree** (n = 221 surveys)	**Lowland Riparian** (n = 211 surveys)	**Mesquite-Catclaw** (n = 116 surveys)	**Mojave Scrub** (n = 147 surveys)	**Montane Riparian** (n = 49 surveys)	**Montane Sagebrush** (n = 8 surveys)	**Montane Shrublands** (n = 39 surveys)	**Pinyon-Juniper** (n = 116 surveys)	**Salt Desert** (n = 68 surveys)	**Number of Habitats Used**
American Pipit	2.52											0.83	**2**
Cedar Waxwing					0.11								**1**
Phainopepla	**1.38**			**0.55**	**2.96**	**2.5**	**0.12**	**0.05**		X	**0.03**	**0.15**	**9**
Black-and-White Warbler					X								**1**
Orange-crowned Warbler		1.02	0.08	0.05	0.11	0.1	0.02				0.06		**7**
Lucy's Warbler	2.07				6.22	1.03	0.02	0.05		0.03	0.01	0.02	**8**
Nashville Warbler					0.02	0.01							**2**
Virginia's Warbler		1.76	0.73		0.05	0.02		1.54		1.24	0.22		**7**
MacGillivray's Warbler		0.73	0.08	0.05	0.12	0.08	0.01	0.05		0.26	0.03		**9**
Common Yellowthroat	1.51				2.49	X					0.01		**4**
American Redstart								0.11					**1**
Yellow Warbler	1.63	0.44	X	0.05	4.59	0.33		0.05		0.07	0.05	0.04	**10**
Yellow-rumped Warbler	0.57	9.81	6.45	0.04	0.76	0.04	0.04	2.28		0.69	0.32		**10**
Grace's Warbler		X	0.64		0.01			0.37					**4**
Black-throated Gray Warbler			1.65	0.04	0.04			5.81		5	4.57		**6**
Townsend's Warbler				0.02	0.03	0.08	0.03	0.03		0.03	0.03		**7**
Hermit Warbler											0.02		**1**
Wilson's Warbler	0.2			0.19	1.01	1	0.11	0.16		0.42	0.2	0.11	**9**
Yellow-breasted Chat	0.85				3.15	0.04							**3**

Species	**Agriculture** (n = 33 surveys)	**Aspen** (n = 10 surveys)	**Coniferous Forest** (n = 49 surveys)	**Joshua Tree** (n = 221 surveys)	**Lowland Riparian** (n = 211 surveys)	**Mesquite-Catclaw** (n = 116 surveys)	**Mojave Scrub** (n = 147 surveys)	**Montane Riparian** (n = 49 surveys)	**Montane Sagebrush** (n = 8 surveys)	**Montane Shrublands** (n = 39 surveys)	**Pinyon-Juniper** (n = 116 surveys)	**Salt Desert** (n = 68 surveys)	**Number of Habitats Used**
Green-tailed Towhee		5.56	2.12	0.16	0.08	0.06	0.17	1.88		0.52	0.47		**9**
Spotted Towhee		0.44	2.88	0.17	1.03		0.07	14.54		9.3	7.6		**8**
Rufous-crowned Sparrow											0.01		**1**
Abert's Towhee	3.91				4.85	0.02	0.04			0.07		X	**6**
Chipping Sparrow	X	9.95	9.1	0.08	0.15	0.02	0.19	6.5		1.27	1.34	0.68	**11**
Brewer's Sparrow	X		0.06	1.43	0.53	1.81	1.11	0.21		0.95	0.52	0.36	**10**
Black-chinned Sparrow		0.15	0.14	0.13	0.27	0.06		1.22	0.16	1.6	1.62		**9**
Vesper Sparrow				0.02	0.01		0.04				0.08		**4**
Lark Sparrow				0.07	0.01	0.01	0.02				0.01		**5**
Black-throated Sparrow	0.04		0.34	15.38	2.22	12.08	15.43	1.64	11.3	5.03	3.74	9.75	**11**
Sagebrush/Bell's Sparrow			X	0.01		0.41	0.05	0.4			0.02	0.09	**7**
Lark Bunting						X							**1**
Savannah Sparrow	0.28					0.01						0.09	**3**
Song Sparrow	2.77				3.44	0.04	0.02	0.03			0.06		**6**
Lincoln's Sparrow					0.01								**1**
White-crowned Sparrow	0.45		0.03	0.41	0.44	0.37	0.06			0.39	0.13		**8**
Golden-crowned Sparrow											0.02		**1**
Dark-eyed Junco		9.07	8.32	X	0.09			2.39		0.29	0.51	X	**8**
Hepatic Tanager					0.01								**1**

Species	Agriculture (n = 33 surveys)	Aspen (n = 10 surveys)	Coniferous Forest (n = 49 surveys)	Joshua Tree (n = 221 surveys)	Lowland Riparian (n = 211 surveys)	Mesquite-Catclaw (n = 116 surveys)	Mojave Scrub (n = 147 surveys)	Montane Riparian (n = 49 surveys)	Montane Sagebrush (n = 8 surveys)	Montane Shrublands (n = 39 surveys)	Pinyon-Juniper (n = 116 surveys)	Salt Desert (n = 68 surveys)	Number of Habitats Used
Summer Tanager					**0.2**					**0.07**			**2**
Western Tanager	0.12	3.51	5.86	0.04	0.25	0.11		3.05		0.46	0.66	X	**10**
Rose-breasted Grosbeak							X						**1**
Black-headed Grosbeak	0.04	2.2	2.46	0.06	0.67	0.1	0.03	4.16		3.23	1.75		**10**
Blue Grosbeak	**0.28**				**1.07**						**0.01**		**3**
Lazuli Bunting	0.12		0.03	0.01	0.39	0.08	0.02	0.24		1.21	0.1	0.02	**10**
Indigo Bunting	0.08				0.28	0.03		0.03			0.01		**5**
Red-winged Blackbird	5.13				5.01	0.02	0.03					X	**5**
Western Meadowlark	6.63			0.06	0.71	X	0.02		X		0.05	0.68	**8**
Yellow-headed Blackbird	0.69				0.21		X						**3**
Brewer's Blackbird	3.82				0.09	X	0.01					X	**5**
Common Grackle				0.01									**1**
Great-tailed Grackle	3.95				0.84	0.08	0.01				X		**5**
Brown-headed Cowbird	5.08		0.28	0.04	4.57	0.72	X	1.51		0.62	0.76	0.02	**10**
Hooded Oriole	0.04			0.01	0.07	0.04				0.07			**5**
Bullock's Oriole	0.89			0.08	0.97	0.19	0.03	X		0.03	0.08	X	**9**
Scott's Oriole	0.04			2.05	0.09	0.34	0.16	X	1.27	2.02	1.09	0.11	**10**
Pine Grosbeak			0.28					0.05					**2**
Cassin's Finch		6.29	7.48	0.03	0.03			2.52		0.29	0.36		**7**
House Finch	5.94		X	1.5	4.19	2.58	1.37	1.17	0.32	0.95	1.62	0.15	**11**
Red Crossbill			0.36					X					**2**

Species	Agriculture (n = 33 surveys)	Aspen (n = 10 surveys)	Coniferous Forest (n = 49 surveys)	Joshua Tree (n = 221 surveys)	Lowland Riparian (n = 211 surveys)	Mesquite-Catclaw (n = 116 surveys)	Mojave Scrub (n = 147 surveys)	Montane Riparian (n = 49 surveys)	Montane Sagebrush (n = 8 surveys)	Montane Shrublands (n = 39 surveys)	Pinyon-Juniper (n = 116 surveys)	Salt Desert (n = 68 surveys)	Number of Habitats Used
Pine Siskin		0.88	1.51					0.24		0.03	0.05		**5**
Lesser Goldfinch	0.89	0.44	0.42	0.02	1.17	0.07	0.35	0.4		0.56	0.41		**10**
Lawrence's Goldfinch						0.02							**1**
American Goldfinch				0.04									**1**
House Sparrow	25.67			X	0.2	0.03	X					0.26	**6**
Average Estimated Densities	**1.66**	**2.57**	**1.45**	**0.5**	**0.66**	**0.65**	**0.47**	**1.26**	**1.57**	**0.92**	**0.6**	**0.65**	
Total Species Richness	**94**	**49**	**78**	**93**	**167**	**88**	**79**	**86**	**18**	**81**	**106**	**51**	