Survey methods, habitat models, and future directions for conservation of Bendire's and LeConte's Thrashers: Comprehensive report of region-wide surveys in 2017-2018.

Photo by Bobby Wilcox

Prepared by the Great Basin Bird Observatory, ammon@gbbo.org

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E.M. Ammon[1], D.M. Fletcher[1], L.B. Harter[1],C.C. Borgman[2], E. Duvuvuei[3], G. Geupel[4], D. Jongsomjit[4], E. Juarez[5], C.L. Kondrat[5], E. Masters[6], and R. Norvell[7] 2020. Survey methods, habitat models, and future directions for conservation of Bendire's and LeConte's Thrashers: A comprehensive report of region-wide surveys in 2017-2018. GBBO Gen. Tech. Report 2019-1. Great Basin Observatory, Reno, NV.

1 Great Basin Bird Observatory, 2 U.S. Fish and Wildlife Service, Division of Migratory Birds, 3 New Mexico Department of Game and Fish, 4 Point Blue Conservation Science, 5 Arizona Game and Fish Department 6 Bureau of Land Management, Arizona State Office, 7 Utah Division of Wildlife Resources

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Summary

Bendire's and LeConte's thrashers are among the fastest-declining species in the arid Southwest, and they are therefore widely recognized as species of continental concern as well as Species of Greatest Conservation Need (SGCN) by most of the southwestern U.S. states. Both species present challenges to research and monitoring in that (1) they are scarcely scattered across large swaths of landscape, (2) they nest earlier than most other landbirds, and (3) they use food resources that are often ephemeral, thus forcing them to occupy different nesting areas from year to year. Therefore, little is known about how to adequately address the urgent conservation needs of these species.

Recognizing this major knowledge gap, agency partners, researchers, and non-profit organizations of the desert Southwest formed the Desert Thrasher Working Group (DTWG) in 2011 with the explicit goal of addressing knowledge gaps to advance effective conservation action by land managers. Specifically, the group designed standardized inventory, monitoring, and centralized data management protocols that addresses basic needs for driving conservation of the species forward. Secondly, the group compiled and vetted all historic location data to create the first generation of spatial habitat suitability models for the two species. Finally, five states (Arizona, California, Nevada, New Mexico, and Utah) implemented the survey protocol in 2017 and 2018 to generate an updated distribution map and conduct a vegetation analysis to describe the birds' breeding habitats.

This report summarizes the methods and results of the surveys conducted in both years, the spatial habitat suitability models, and the survey data analysis. The DTWG developed a time- and area-limited area search survey approach based on methods used to survey LeConte's Thrasher in the Carrizo Plain by Point Blue Conservation Science (Tietz et al. 2016). The study area was delineated and stratified using the spatial habitat suitability models developed for each species, and survey plots were randomly selected on public lands. Of all plots surveyed (n = 841),

A total of 841 unique plots were surveyed in this study, with the majority (76 percent) occurring on Bureau of Land Management (BLM) lands (n = 635). In 2017, 1,082 surveys were conducted on 385 plots in Arizona, California, and Nevada. In 2018, 1,363 surveys were conducted on 507 plots in Arizona, California, Nevada, New Mexico and Utah. Of the 841 plots, 57 were occupied by Bendire's Thrasher (193 detections) and 131 were occupied by LeConte's Thrasher (665 detections). We summarized vegetation data collected at the survey plots to illustrate how the birds are using landscapes region-wide. We also used the vegetation data to perform region-wide logistic regressions, and the model outputs explained only 12.8 percent of the variation in Bendire's Thrasher and 37.5 percent of the variation in LeConte's Thrasher habitat use.

While this two-year study updated our current understanding of both species' distributions, their habitat use, and their relative densities on the landscape, the DTWG also concluded that

these difficult-to-study species require further research and monitoring to pinpoint important ecoregional differences in habitat use, threats to the species, and specific strategies to drive local conservation action.

As a result, the group developed the following recommendations for continuing the work on addressing the urgent conservation needs of Bendire's and LeConte's thrashers:

1. Combine and analyze 2017 and 2018 survey data and historic thrasher data at an ecoregional scale where sufficient location data exist.
2. Analyze 2017 and 2018 survey data to investigate how thrasher occupancy correlates with Assessment, Inventory, and Monitoring (AIM) data from the BLM's Database for Inventory, Monitoring and Assessment (DIMA), which includes measures of vegetation and soil condition, such as plant species cover and composition, plant height, and soil stability.
3. Cross-reference 2017 and 2018 survey data with relevant BLM spatial management tools to investigate how the strategies they represent affect thrasher occupancy. Spatial layers that may be considered for analysis include desert tortoise critical habitat, burro density maps, and maps of conservation management units for various other goals.
4. Use the 2017 and 2018 survey data to ground-truth and strengthen the first-generation spatial habitat suitability models and explore the option of scaling the current region-wide model into smaller ecoregional models.
5. Conduct additional surveys in under-surveyed areas to further clarify distribution and habitat use in all occupied ecoregions, and include a measure for estimating detectability of each thrasher species.
6. Explore options of integrating thrasher surveys into other ongoing bird monitoring programs, such as the Integrated Monitoring of Bird Conservation Regions (IMBCR) program or other similar multi-species survey programs.

The work presented in this report was done in collaboration by partners from federal and state agencies and from the non-profit and private sector working together as the Desert Thrasher Working Group. Information on the group's mission, list of active partners, and resources can be found on a page of the Borderlands Avian Data Center (http://borderlandsbirds.org/).

Acknowledgments

This project was funded by the U.S. Bureau of Land Management with matches from state and non-profit partners of Arizona, California, Nevada, New Mexico, and Utah. This project was jointly developed and implemented by members of the Desert Thrasher Working Group. This report benefited from review by Sandra Brewer, John Boone, Keith Day, J.A. Vacca, and Geoff Walsh.

Introduction

Bendire's and LeConte's thrashers (*Toxostoma bendirei* and *T. lecontei*) are among the fastest-declining bird species in North America (Rosenberg et al. 2016, Sauer et al. 2017), and their global populations are restricted to the landscapes of the arid Southwest, which has experienced significant conservation threats over the past several decades (NABCI 2016, Iknayan and Beissinger 2018). Their populations are estimated to have declined by 87 percent and 67 percent, respectively, in the past 45 years (Rosenberg et al. 2016), and the 'population half-life' (i.e., time to a further 50 percent population decline) is estimated to be only 14 years for Bendire's Thrasher and 29 years for LeConte's Thrasher (Stanton et al. 2016). Due to the thrashers' scarcity across the landscape, their secretive nesting habits, and their reliance on ephemeral food and water sources in harsh desert environments (England and Laudenslayer 1993, Sheppard 2018), our understanding of their habitat and conservation needs is inadequate, which limits effective species management.

In recognition of these sharp population declines, landscape threats, and globally restricted populations, the two thrashers are widely recognized as species in need of urgent conservation action. The Bendire's Thrasher is ranked internationally as an IUCN Red List (Vulnerable) species (Birdlife International 2017). Both thrasher species are a Red Watch List Species by Partners in Flight (Rosenberg et al. 2016) and a U.S. Fish and Wildlife Service (USFWS) national Bird of Conservation Concern (USFWS 2008). Both species are also listed as U.S. Bureau of Land Management (BLM) Sensitive Species in the states where they occur, and the Sonoran Joint Venture lists both thrashers as species of continental concern requiring management attention (SJVTC 2006).

At the state level, the Bendire's Thrasher is recognized as a Species of Greatest Conservation Need (SGCN) or equivalent designations in the State Wildlife Action Plans (SWAPs) of all U.S. states where they occur (Arizona, California, Nevada, New Mexico and Utah; AGFD 2012, WAPT 2012, CDFW 2015, UWAPJT 2015, NMDGF 2016). The LeConte's Thrasher is identified as an SGCN in the SWAPs for Arizona, California, and Nevada.

All SWAPs identify the need for additional information and development of management actions that advance conservation of these species, while also emphasizing an overall lack of sufficient monitoring that would elucidate population sizes, trend estimates, and habitat requirements of both thrashers (for details on SWAP priorities, see Appendix 1). This lack of knowledge limits the efficient assessment of conservation needs and stymies targeted on-the-ground conservation.

The widespread recognition of the urgent need for better scientific information and guidance for conservation led to the formation of the Desert Thrasher Working Group (DTWG) in 2011. The group embraces the spirit of Partners in Flight's simple and proactive mission: *Keeping common birds common and helping species at risk through voluntary partnerships*. The DTWG is composed of 16 agency, research, and NGO partners throughout the southwest (Table 1), who

now provide an active network for sharing current science on the species, developing optimized monitoring strategies, conducting habitat suitability modeling, and identifying any Best Management Practices for Bendire's and LeConte's thrashers.

Table 1. Current partners and their roles in the Desert Thrasher Working Group. Partners listed in alphabetic order.

Organization	Roles in the DTWG
Arizona Game and Fish Department	Implementation (AZ); study design; protocol development; group coordination
Atwell, Inc.	Study design; protocol development
Audubon Arizona	Study design; public engagement
Great Basin Bird Observatory	Implementation (NV); study design; data management; data analysis; group coordination; report preparation
Griffin Biological Services	Study design
Nevada Department of Wildlife	Implementation (NV)
New Mexico Game and Fish Department	Implementation (NM); study design
New Mexico State University	Study design; protocol development
Partners in Flight, Western Working Group	Discussion forum and group networking
Point Blue Conservation Science	Implementation (CA); study design; protocol development; data management; modeling; data analysis; public engagement
Sonoran Joint Venture	Group coordination; study design; public engagement; data management
Tucson Audubon	Public engagement; volunteers
U.S. Bureau of Land Management	Study design; funding
U.S. Fish and Wildlife Service	Study design; group coordination
U.S. Forest Service	Study design
Utah Division of Wildlife Resources	Implementation (UT); study design; protocol development

In 2016, the DTWG received funding from the BLM (with match provided by partners) to develop a standardized survey protocol for both thrashers and to conduct surveys (2017 and 2018) on randomly selected sites throughout their U.S. ranges. The DTWG ranked this project as the highest priority, recognizing that having a standardized survey method would significantly contribute to efforts to more comprehensively research and monitor both species and their habitats. While some established bird monitoring programs can detect thrasher population trends (e.g., the national Breeding Bird Survey [BBS]), none of the existing protocols address several unique challenges posed by the two thrashers: most importantly, their nesting

season occurs prior to most other landbirds, and existing monitoring strategies would result in collection of post-breeding data. Targeting data collection to the thrasher nesting season would allow for habitat suitability modeling and detection of distributional changes more relevant to their conservation (Fitton 2008). Other challenges to inventory and monitoring of these species include their cryptic behaviors, scarcity across the landscape, and annual variation in site occupancy (England and Laudenslayer 1993, Sheppard 2018), all of which are less of a hindrance when monitoring other songbirds.

The primary objectives for this study were to (1) improve our understanding of the species' breeding distributions, (2) create spatial abundance models, and (3) perform habitat suitability analyses to provide initial guidance on where and how to best manage for these species. A secondary objective was to test the adopted Desert Thrasher Survey Protocol. In the medium and long term, this study will assist in determining population sizes and trends, and in refining habitat and spatial models that can lead to formulating specific management actions and best habitat management practices.

Methods

Sampling Design

Recognizing that Bendire's and LeConte's thrashers are known to be rare on the landscape and difficult to detect on surveys (Weigand and Fitton 2008, Bear Sutton et al. 2017), the defined study area, which included all of the known U.S. breeding ranges of both thrashers, was stratified by likelihood of thrasher occupancy so that survey effort could be optimized. For this, Point Blue Conservation Science (PBCS) created landscape-level habitat suitability (Maxent) models for each of the species based on historic location data and readily available environmental spatial data. The initial models were created in 2017 and then refined in 2018.

Maxent Models 2017

The first round of models included the known range for LeConte's and Bendire's thrashers within California, Arizona, and Nevada. Historic bird presence data for the models was compiled from eBird (filtered records), BBS, Arizona Important Bird Areas, Nevada Bird Count, and two research projects (Fletcher 2009, Jongsomjit et al. 2012), resulting in 742 locations for Bendire's Thrashers and 1,233 locations for LeConte's Thrashers. For the environmental variables predicting habitat suitability, climate data at 1 km resolution (Flick and Hijmans 2017) were processed into climatic summaries for different 4-month long breeding season windows to allow for differences in the timing of breeding. Models were run with total precipitation, temperature range, and mean temperature after examining the correlation between all potential climate variables. Additionally, vegetation data from LandFire (2008), which represents vegetation data from a U.S. wide model of land cover types, were included. The LandFire data were rescaled to match the 1 km resolution of the climate data layer.

The species habitat suitability models were created using Maxent v3.3.3k, which was designed to model presence-only data. A 10-fold cross-validation for each species was used to assess model performance. The mapped results of each of the models were then averaged across all 10 models (Figures 1 and 2).

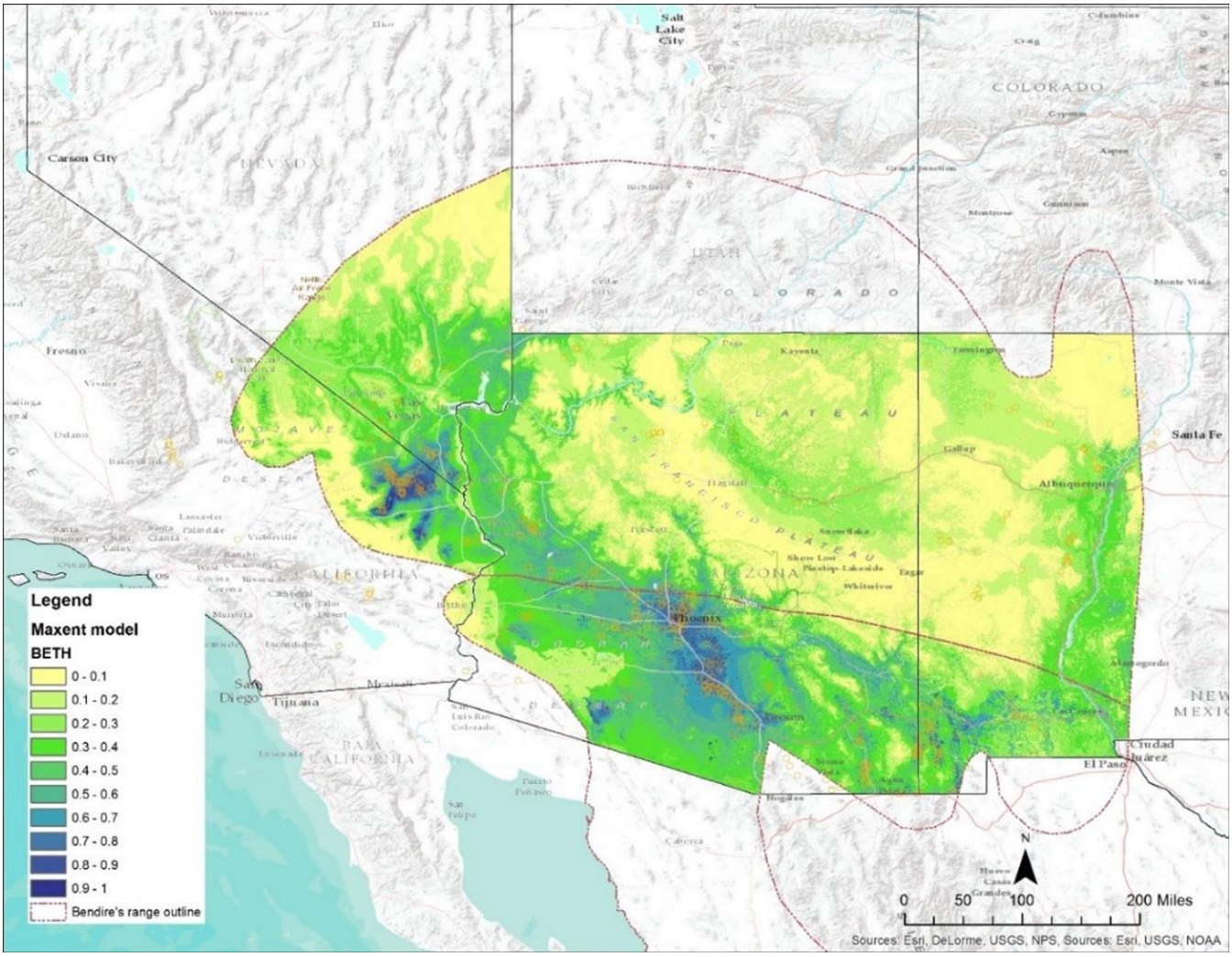

Figure 1. Maxent model created for Bendire's Thrasher survey plot selection in 2017. Darker colors represent a higher modeled habitat suitability.

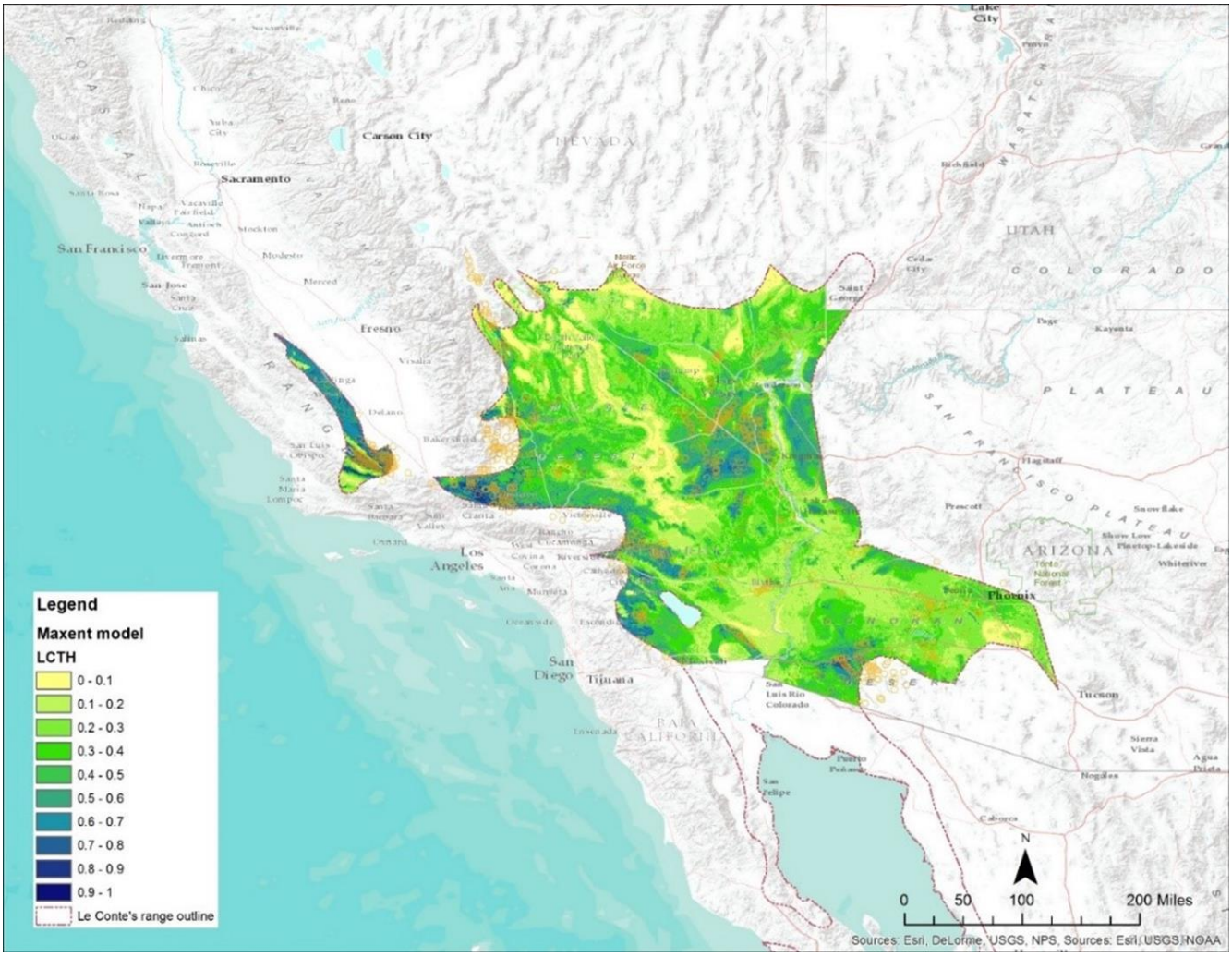

Figure 2. Maxent model created for LeConte's Thrasher survey plot selection in 2017. Darker colors represent a higher modeled habitat suitability.

Maxent Models 2018

In 2018, the Maxent models were revised to include the 2017 survey data, expanded portions of the thrashers' ranges, and additional environmental variables deemed useful for improving model outputs. Environmental variables added in 2018 included distance to streams (based on National Hydrography dataset (U.S. Geological Survey 2004), elevation, slope, and an index of surface ruggedness. Additional thrasher location records were also included from various sources including historic PBCS records, data from the California Natural Diversity Database, eBird, Arizona Important Bird Areas, and data provided from miscellaneous sources by Utah and New Mexico, in all totaling 1,655 LeConte's Thrasher locations and 962 Bendire's Thrasher locations (Figures 3 and 4). As with the 2017 models, these 2018 models were created to define the study area and improve the targeting of particular survey strata.

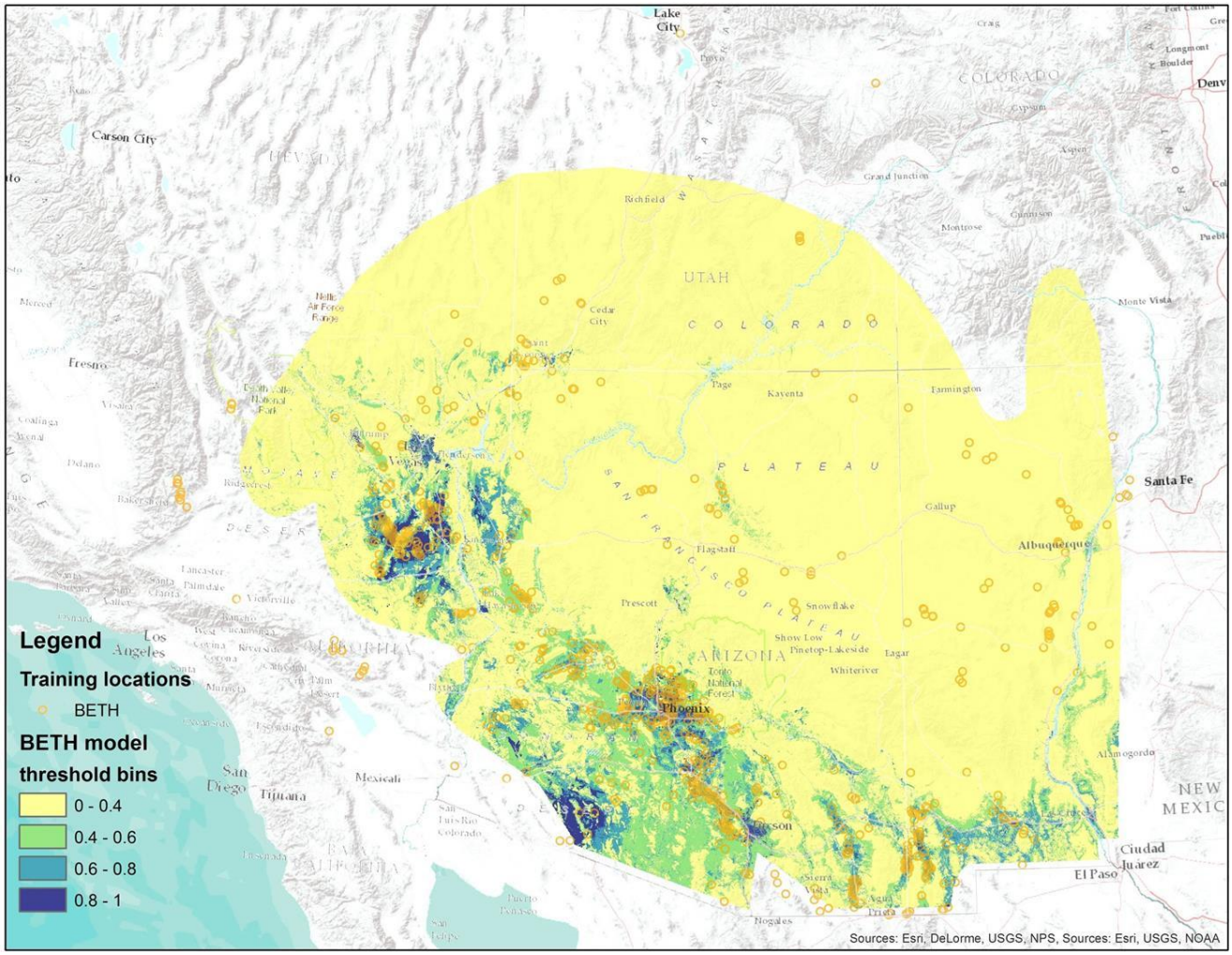

Figure 3. Maxent model created for Bendire's Thrasher survey plot selection in 2018. Colors represent modeled habitat suitability grouped into four bins with darker colors representing higher suitability.

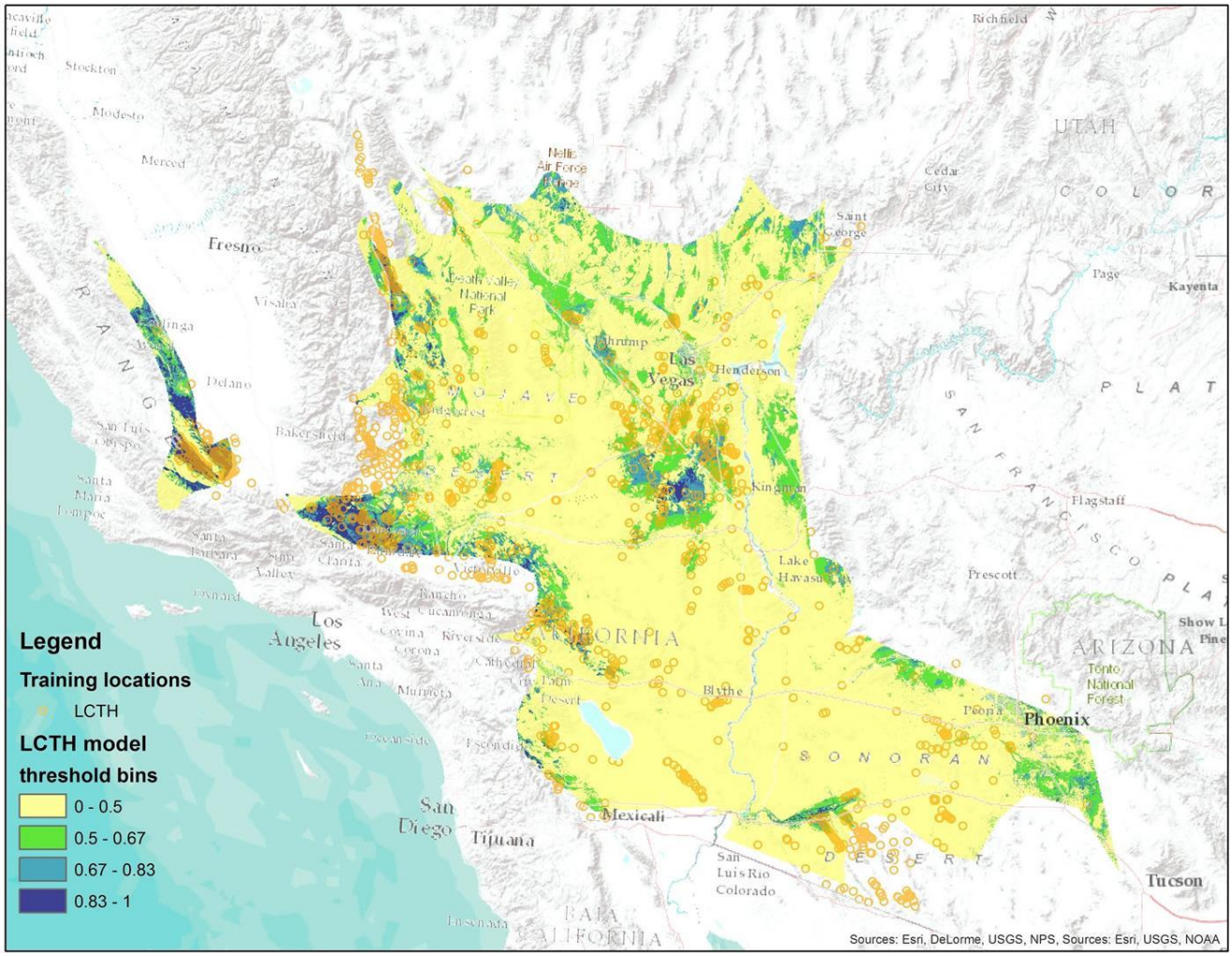

Figure 4. Maxent model created for LeConte's Thrasher survey plot selection in 2018. Colors represent modeled habitat suitability grouped into four bins with darker colors representing higher suitability.

The study area was gridded into 300 x 300 m plots aligned with the Universal Transverse Mercator (UTM) grid system. Each plot was attributed with the species model values of suitability and classified as high, medium, low, or no suitability, with these thresholds defined by expert opinion (Figures 3, 4, and 5). Plot selection was further restricted to plots that were greater than 200 m from a major highway, less than 4 km from an access road, and primarily on BLM lands (unless directed otherwise by the state). It was anticipated that a two-person crew could survey three plots each in one morning in a given area. Therefore, plots were selected in clusters of up to six plots (with spacing between plots of at least 300 m), with additional plots that could be used as alternates for inaccessible plots. Once the number of potential survey plots was determined, plots were randomly selected as follows: (1) in 2017, only high suitability plots were selected, but (2) in 2018, plots were also selected from the medium, low, and no suitability categories. The additional suitability categories were included in the second year due to the limited number of plots classified as "high suitability" for Bendire's Thrasher (0.009 percent of all plots). In summary, the 2018 plots were selected from suitability categories as follows: 60 percent from high, 20 percent from medium, 10 percent from low, and 10 percent

from no suitability. The final 2018 plots consisted of new plots selected according to plan and any 2017 plots where thrashers had been recorded.

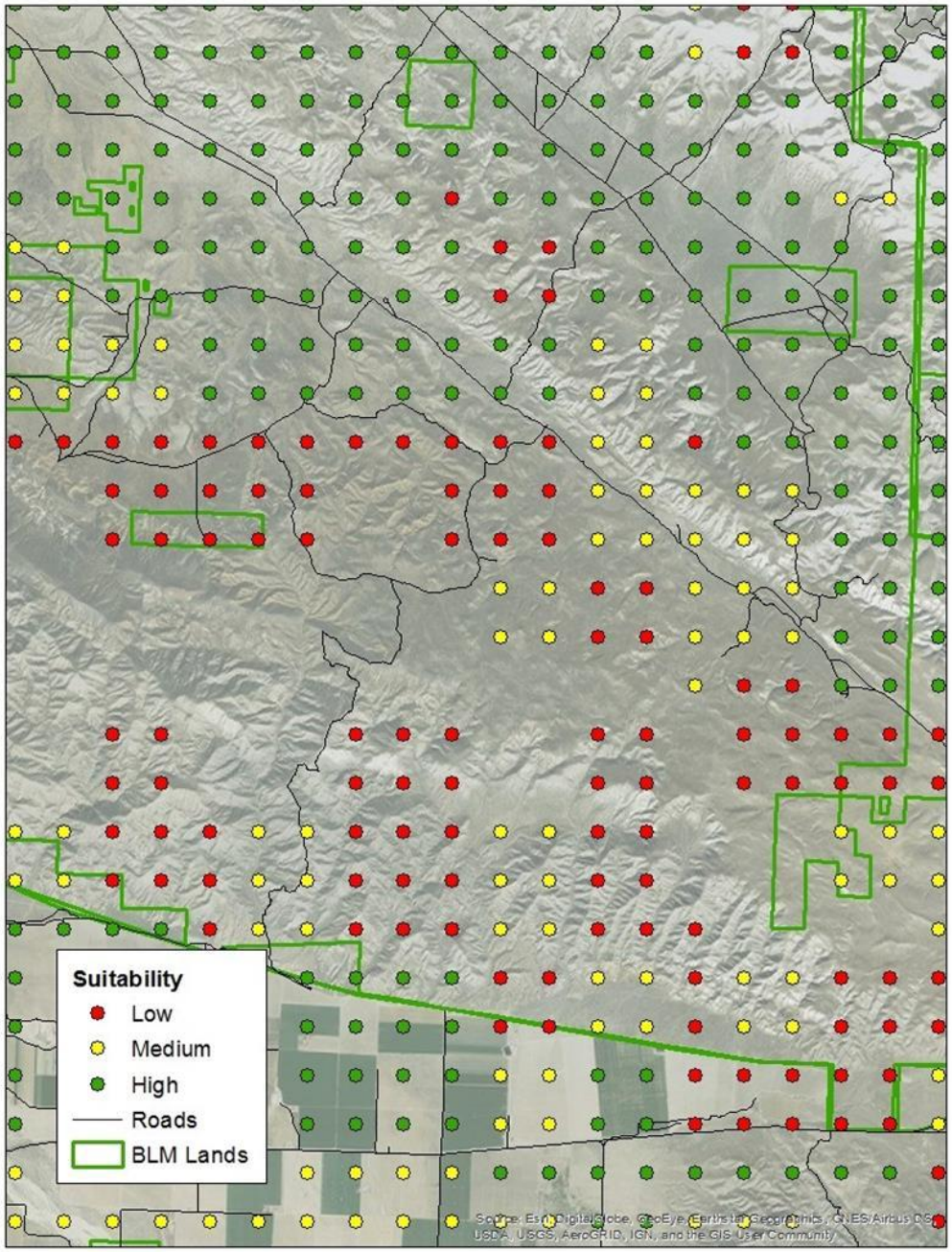

Figure 5. Example of desert thrasher sampling plot center points in different suitability categories.

Survey Methods

Area Search Surveys

Taking into consideration several factors, the DTWG pursued the development of a survey protocol based on an area search approach (Ralph et al. 1993). *Toxostoma* thrashers are cryptic in that they sing infrequently, and tend to walk on the ground more commonly than fly. These life history traits and other factors including low densities, secretive behavior, ventriloquial vocalizations, and early breeding season phenology suggest that point count surveys (including BBS and Integrated Monitoring in Bird Conservation Regions [IMBCR], Pavlacky et al. 2017) do not effectively sample desert thrasher populations (Weigand and Fitton 2008, Bear Sutton et al. 2017) and make meaningful analysis difficult (Jongsomjit et al. 2012). Additionally, existing multi-species monitoring programs that rely on roadside surveys, such as the BBS, may not adequately cover LeConte's or Bendire's thrashers' habitats, and peak singing rates and nest initiation in the southwest can occur several weeks before the BBS April 20 – June 15 survey window (Fitton 2008). Lastly, two previous applications of the area search method for thrasher surveys were successful in achieving monitoring goals (Jongsomjit et al. 2012, Corman et al. 2018).

The Desert Thrasher Survey Protocol was modified from area search methods developed by Point Blue for LeConte's Thrasher surveys conducted in the BLM Carrizo Plain National Monument since 2010 (Jongsomjit et al. 2013, 2014). A brief description of our survey methods is provided below, and the complete protocol can be accessed through the BADC node (http://borderlandsbirds.org/projects/desert-thrasher/) and is in review (McCreedy et al. in review) .

Each plot was surveyed three times during the breeding season (although a few plots only received two surveys due to logistical challenges). An area search survey was conducted on each 300 x 300 m plot in approximately 40 minutes. Surveyors were instructed to focus on detecting Bendire's and LeConte's thrashers as the focal species, but also record numbers and species of all birds heard or seen during the survey. Loggerhead Shrike (*Lanius ludovicianus*) was also included as a focal species, as its inclusion would not impact the detectability of thrashers. However, in this report, we only present survey results for the two thrashers. Plot boundaries were set on UTM coordinates ending in 100s to help surveyors orient themselves with handheld GPS receivers or GPS-enabled digital devices (e.g., tablets or smartphones with ESRI's Collector or Survey123 apps installed). Surveyors walked the plots using north-south transect lines to avoid light interference and backlighting of perched birds in the distance. Transects lines were spaced 50 m on each UTM easting ending with 00 or 50, with the exception of the east and west boundary lines (Figure 6).

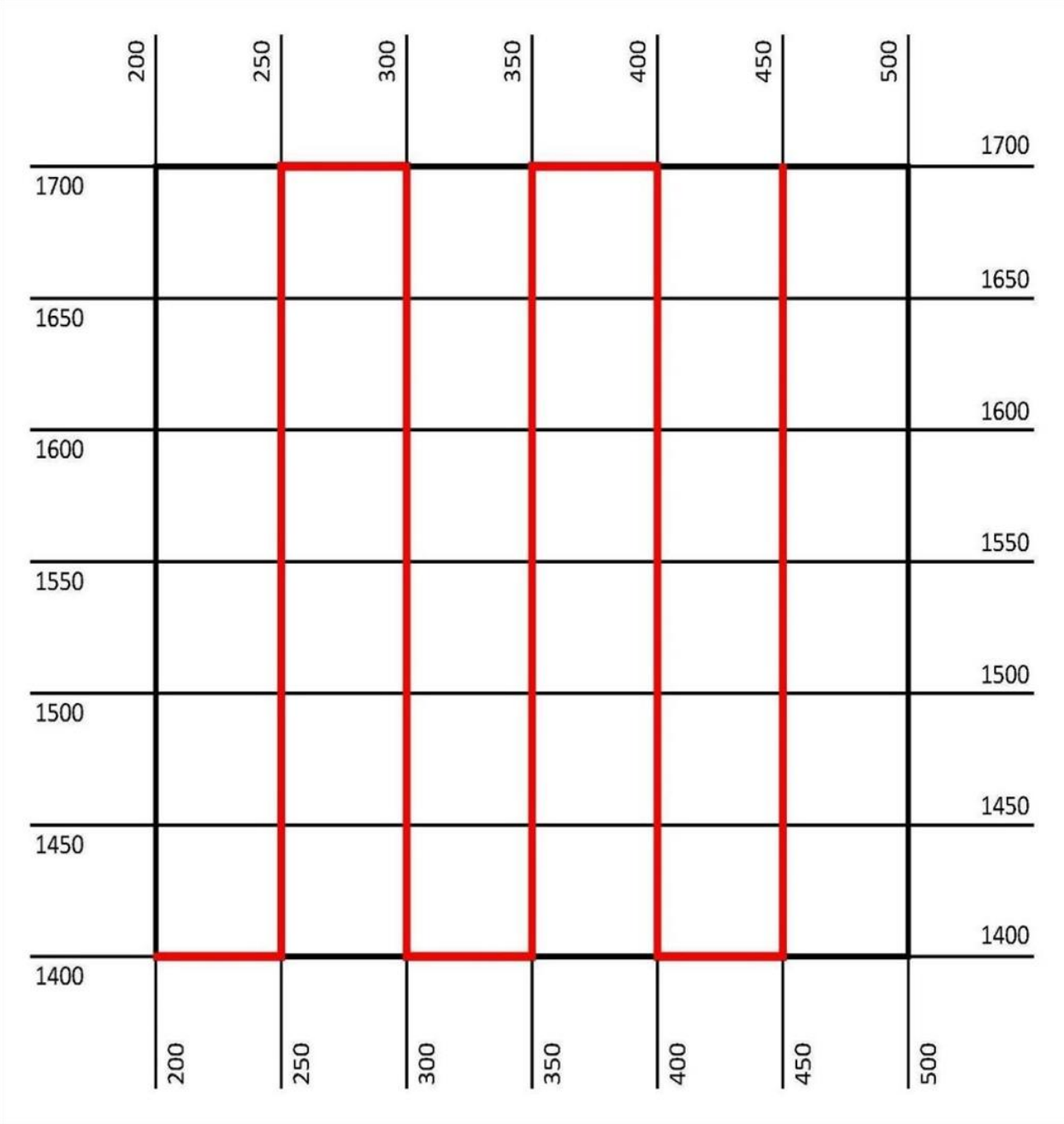

Figure 6. Thrasher survey plot with typical survey route highlighted in red.

While avoiding double-counting, thrashers seen or heard on the plot during the survey were recorded on the survey form datasheet. In addition, every detected thrasher (during or after a survey and on or off the plot), was also recorded on the target species sighting form, where additional details on each observation, such as breeding status, were included.

Plot Vegetation Assessment

The protocol for the thrasher habitat assessments was derived from other protocols used in similar habitat types, but modified to include vegetation and land use variables deemed relevant based on the natural history and known habitat associations of the two species (Corman et al. 2018). Habitat assessments were conducted at the center point of each bird plot surveyed. Some states also completed vegetation assessments at locations of incidental Bendire's Thrasher sightings (i.e., those detected outside a survey and/or outside a plot). Vegetation assessments at incidental record locations were completed at the center of the 300 m x 300 m grid cell containing the bird.

We used the point-centered quarter method to capture vegetation data. From the center point, a compass was used to define the four quarters (northeast, southeast, southwest, and northwest; Figure 7). In each quarter, we measured the distance from the center point to the following plant categories: cholla, yucca, shrubs (≤ 0.5 m height), shrub/trees (> 0.5 m – 2 m height), and trees (> 2 m height).

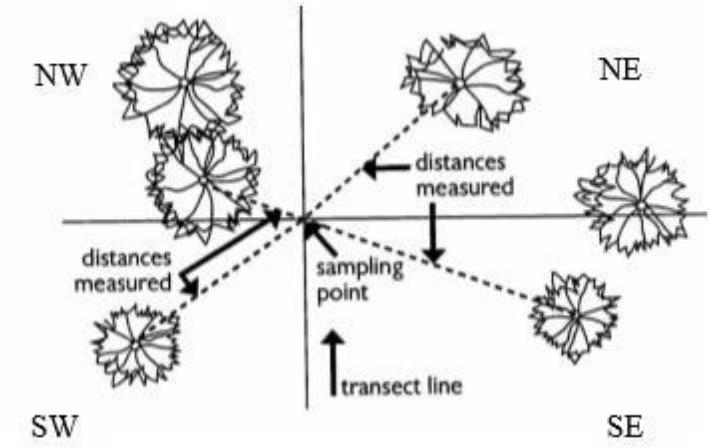

Figure 7. Layout of the point-centered quarter vegetation assessment for desert thrasher survey plots.

In addition to collecting point-centered quarter data, we also recorded other vegetation and land use variables, such as presence of OHV-caused disturbance, composition of ground cover, presence of invasive plants and fruit-bearing trees/shrubs, and presence of ephemeral washes. For a full list of habitat variables included in the vegetation assessments, see the complete protocol at http://borderlandsbirds.org/projects/desert-thrasher/.

Data Analyses

Vegetation Data Analysis

For analysis of the vegetation assessment data from plots with and without thrasher detections, we combined data from 2017 and 2018 and reduced the number of assessment variables using a correlation matrix. We eliminated one of any two variables that correlated with another by 0.7 or more, retaining the variable deemed to be more likely to relate to thrasher habitat selection based on expert opinion.

To estimate plant density from point-centered quarter measurements in each plant category, we took an average of all four distances ($\bar{x}$), then calculated plants per hectare using the formula $(1/(\bar{x}^2))*(10^4)$. In cases where the plant category was present within 1 km in at least one quadrant but absent from at least one other quadrant, we used a truncated value, beyond which we assume that plants in that category become difficult to detect (Thompson et al. 2016). Truncated values were determined based on natural cutoffs in the data, beyond which few data points exist in that category.

We fit logistic regression models by maximum likelihood as implemented in the GLM function in base R (R Core Team 2018). We fit the most complex models first and then proceeded through model simplification. Quadratic expressions of some assessment variables were explored as predictors in the model fitting process. Model simplification proceeded based on Wald Z-tests (Bolker et al. 2009) and evaluation of model fits in relation to summary statistics.

Landscape Model Performance

Although the Maxent models were originally created for the purpose of defining and stratifying the study area, we were also interested in exploring how well the models performed in general to determine if they could be refined to be useful for land management applications. Therefore, we assessed the actual performance of the 2018 version of the models. To determine how well the models predicted whether or not a thrasher would be present at a site, we tabulated the plots with and without thrasher detections according to their predicted suitability for each of the species (Tables 2 and 3).

To test model performance, we completed two logistic regression analyses on each of the species, one to test whether suitability categories and State (as a measure of geographic variation) could predict thrasher presence, and one to test whether suitability as a continuous variable (with values from 0 for no suitability to 1 for maximum suitability) and State could predict thrasher presence. The continuous suitability variable was originally categorized into four suitability bins (no, low, medium, and high) for the purpose of stratifying the study area. These model performance tests should be viewed as a preliminary exploratory exercise. Additional work would be needed to investigate improvements to the spatially predictive models, which was outside the scope of this project.

Data Management and Storage

Project implementers collaborated with PBCS to establish a data project at the California Avian Data Center (a node of the Avian Knowledge Network [AKN]) to capture and manage the thrasher survey data. Direct integration of thrasher data into an AKN node provides a platform for data organization, sharing and coordination of standardized monitoring efforts, as well as data analysis and visualization tools. Currently only the thrasher data is stored in the AKN node, with a future goal of incorporating target species records, vegetation assessments, and Maxent models as feasible. The DTWG page (http://borderlandsbirds.org/), hosted by the Borderlands Avian Data Center, provides access to thrasher project resources, such as protocol, datasheets, and training materials.

Table 2. Detections and non-detections of Bendire's Thrashers in suitability bins assigned to that plot by the 2018 Maxent model.

	no suitability						low suitability						medium suitability						high suitability						
Bendire's Thrasher Detected	**Arizona**	**California**	**New Mexico**	**Nevada**	**Utah**	**Total Bin 0**	**Arizona**	**California**	**New Mexico**	**Nevada**	**Utah**	**Total Bin 1**	**Arizona**	**California**	**New Mexico**	**Nevada**	**Utah**	**Total Bin 2**	**Arizona**	**California**	**New Mexico**	**Nevada**	**Utah**	**Total Bin 3**	**Total**
Yes	1		1			2	1	1				2	3	3	2			8	3	13		10	*	26	38
No	14	15	41	25	22	117	17	6	16	14	12	65	27	9	29	27	14	106	37	46	22	50	*	155	443
Total	15	15	42	25	22	119	18	7	16	14	12	67	30	12	31	27	14	114	40	59	22	60		181	481

Table 3. Detections and non-detections of LeConte's Thrashers in suitability bins assigned to that plot by the Maxent model.

	no suitability				low suitability				medium suitability				high suitability			
LeConte's Thrasher Detected	**Arizona**	**California**	**Nevada**	**Total Bin 0**	**Arizona**	**California**	**Nevada**	**Total Bin 1**	**Arizona**	**California**	**Nevada**	**Total Bin 2**	**California**	**Nevada**	**Total Bin 3**	**Total**
Yes		2	7	9		7	36	43		4	12	16	2		2	70
No	49	29	34	112	40	22	27	89	14	20	9	43	7	1	8	252
Total	49	31	41	121	40	29	63	132	14	24	21	59	9	1	10	322

Results

Region-Wide Survey Results

During the 2017 and 2018 thrasher breeding seasons, a combined total of 2,440 surveys were conducted on 841 plots distributed across five states. We recorded a total of 193 Bendire's Thrasher detections in 57 unique plots (a subset of plots were surveyed in both years) plus incidental detections, and a total of 665 LeConte's Thrasher detections in 131 unique plots plus incidental detections (Tables 4 and 5). For data analyses, we only included observations made during surveys, and excluded all incidental records, resulting in 119 LeConte's Thrashers detections and 50 Bendire's Thrasher detections. For LeConte's Thrasher, 91 were only observed on one visit, 23 on two and five on all three visits. Of the 50 Bendire's Thrashers detected on plot during survey, 40 were observed on only one visit, eight on two visits, and only two on all three visits to the plot.

Aside from desert thrashers, 180 other species were recorded during all surveys in the five states (Appendix 2) totaling 29,825 bird detections. The ten most commonly detected species were Black-throated Sparrow (n = 7,394), Brewer's Sparrow (n = 2,996), Horned Lark (n = 1,545), White-crowned Sparrow (n = 1,529), Ash-throated Flycatcher (n = 1,110), House Finch (n = 1,049), Cactus Wren (n = 921), Black-tailed Gnatcatcher (n = 873), and Verdin (n = 818).

Table 4. Thrasher detections on plot surveys by state, 2017.

			LeConte's Thrasher		Bendire's Thrasher	
State	**Plots Surveyed**	**Vegetation Surveys**	**On Plot**	**Total Records**	**On Plot**	**Total Records**
Arizona	70	69	n/a	n/a	16	50
California	56	56	9	27	4	13
Nevada	259	256	60	310	3	16
Total	**385**	**381**	**69**	**337**	**23**	**79**

Table 5. Thrasher detections on plot surveys by state, 2018.

			LeConte's Thrasher		Bendire's Thrasher	
State	**Plots Surveyed**	**Vegetation Surveys**	**On Plot**	**Total Records**	**On Plot**	**Total Records**
Arizona	126	130	1	3	10	28
California	93	60	14	45	15	51
Nevada	126	136	48	280	9	27
New Mexico	111	111	n/a	n/a	1	7
Utah	51	52	0	0	0	1
Total	**507**	**489**	**63**	**328**	**35**	**114**

Survey Results by State

Arizona

In Arizona, Department of Defense (DoD) lands contain significant portions of LeConte's Thrasher habitat, and the species has been well studied on these lands. For this reason, Arizona chose to primarily focus on Bendire's Thrasher, and DoD lands were excluded from plot selection. In 2017 and 2018, Arizona conducted 521 surveys in 172 unique plots, 20 of which were surveyed in both years (Table 2 and 3). Arizona detected 116 species including 78 detections of Bendire's Thrashers and 3 detections of LeConte's Thrashers. Bendire's Thrashers occupied 26 plots and LeConte's Thrashers 1 plot. In addition to thrashers, a total of 6,111 detections of 116 species were recorded in Arizona (Appendix 2).

California

In 2017 and 2018, California conducted 342 surveys on 127 unique plots, 22 of which were surveyed in both years, and plots were selected from both species' suitability models. California had 64 detections of Bendire's Thrasher on 19 plots and 72 LeConte's Thrasher detections on 23 plots. California recorded 4,910 detections of a total of 96 species on surveys (Appendix 2).

Nevada

Nevada conducted 1,129 surveys in 379 unique plots (6 plots were visited in both years) selected from both species' suitability models in 2017 and from the Bendire's Thrasher model only in 2018 (Table 2 and 3). Nevada had 43 detections of Bendire's Thrashers on 12 plots and 590 detections of LeConte's Thrashers on 108 plots. In addition to the thrashers, Nevada recorded 13,607 individuals of 134 species (Appendix 2).

New Mexico

New Mexico joined the survey effort in 2018 and conducted 279 surveys on 108 plots, resulting in one detection of Bendire's Thrasher on one survey plot and six incidental detections. LeConte's Thrasher does not range into New Mexico. Additionally, New Mexico recorded 4,612 individual birds of 105 species (Appendix 2).

Utah

Utah also joined the survey effort in 2018 and conducted 151 surveys on 51 plots selected from the Bendire's Thrasher suitability model. Utah recorded one Bendire's Thrasher detection on one plot and a total of 998 individuals of another 47 species (Appendix 2).

Ecoregional Distribution of Thrasher Records

Although survey plots for thrashers were distributed across nine ecoregions, thrashers were only found in six, the Mojave Basin and Range (Figure 8), Sonoran Basin and Range (Figure 9), Chihuahuan Desert (Figure 10), Arizona/New Mexico Mountains (Figure 11), Central Basin and Range (Figure 12), and Madrean Archipelago (Figure 13). The majority of thrasher detections from the project occurred in the Mojave, Sonoran, and Madrean Archipelago ecoregions. While these three ecoregions contain known “hotspots” for both species, some other areas, particularly the Chihuahuan Desert, were likely underrepresented due to state-specific allocations of survey effort in this two-year project.

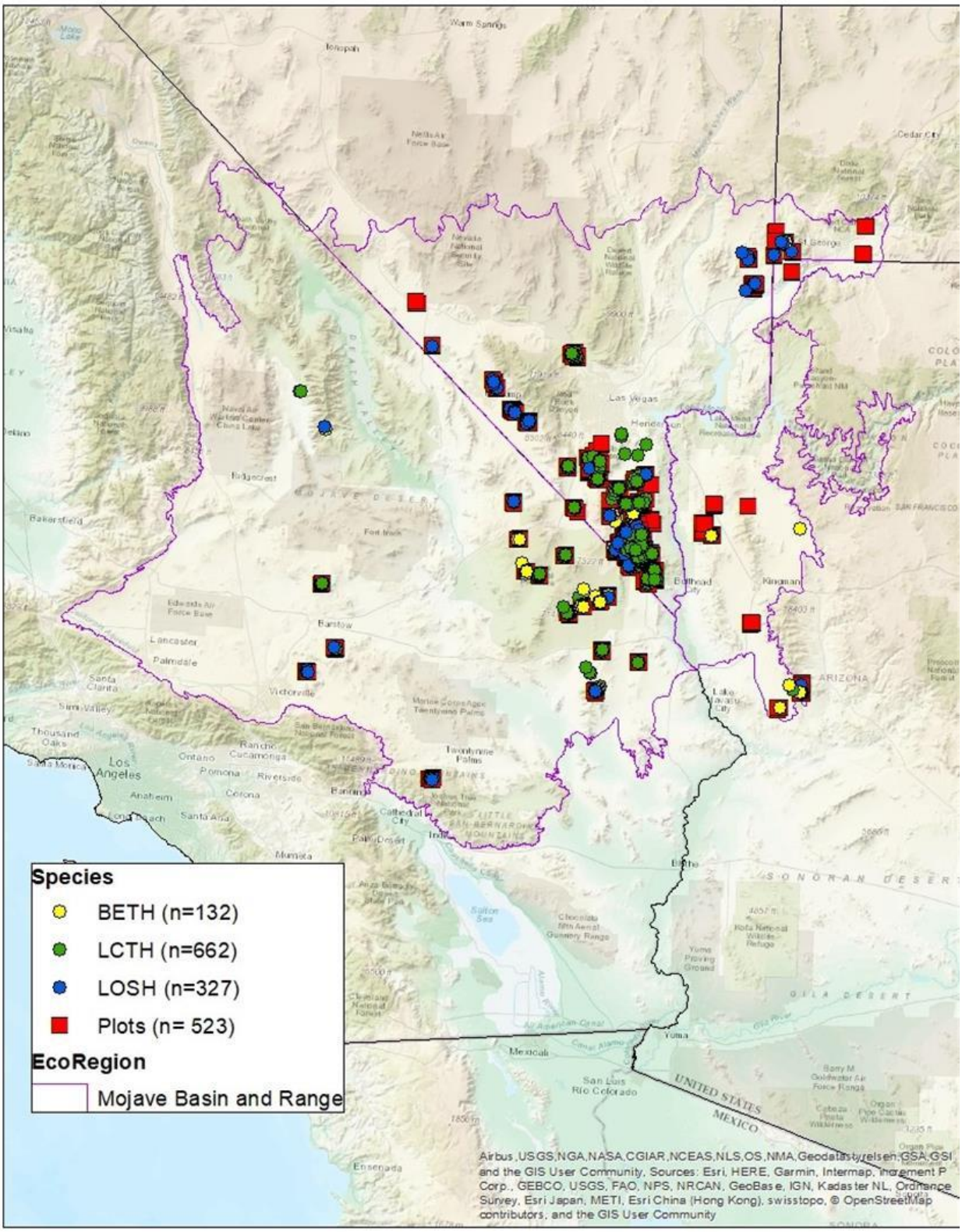

Figure 8. Plots surveyed and species detected during thrasher surveys in the Mojave Basin and Range ecoregion, 2017-2018. BETH = Bendire's Thrasher, LCTH = LeConte's Thrasher, LOSH = Loggerhead Shrike.

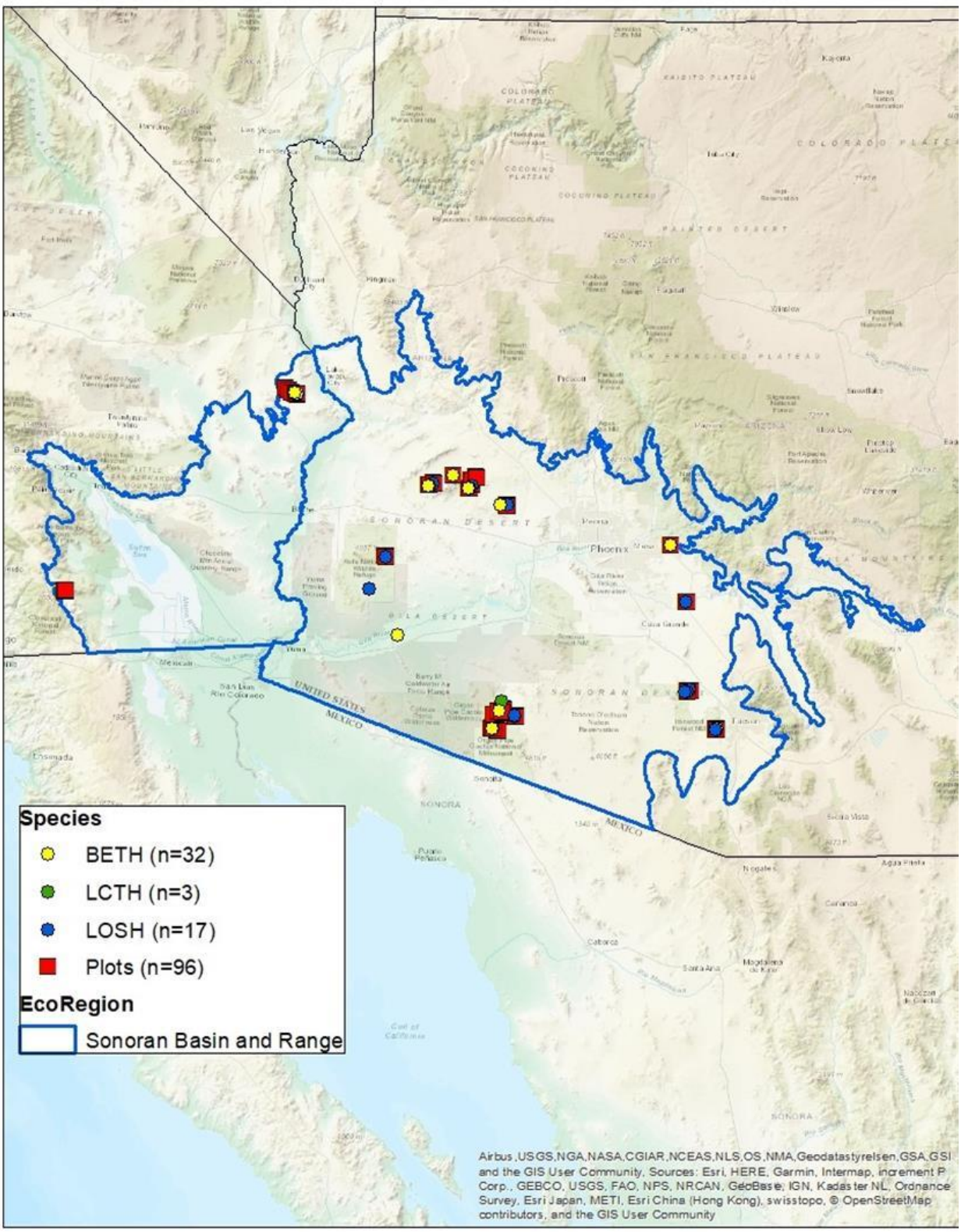

Figure 9. Plots surveyed and species detected during thrasher surveys in the Sonoran Basin and Range ecoregion, 2017-2018. BETH = Bendire's Thrasher, LCTH = LeConte's Thrasher, LOSH = Loggerhead Shrike.

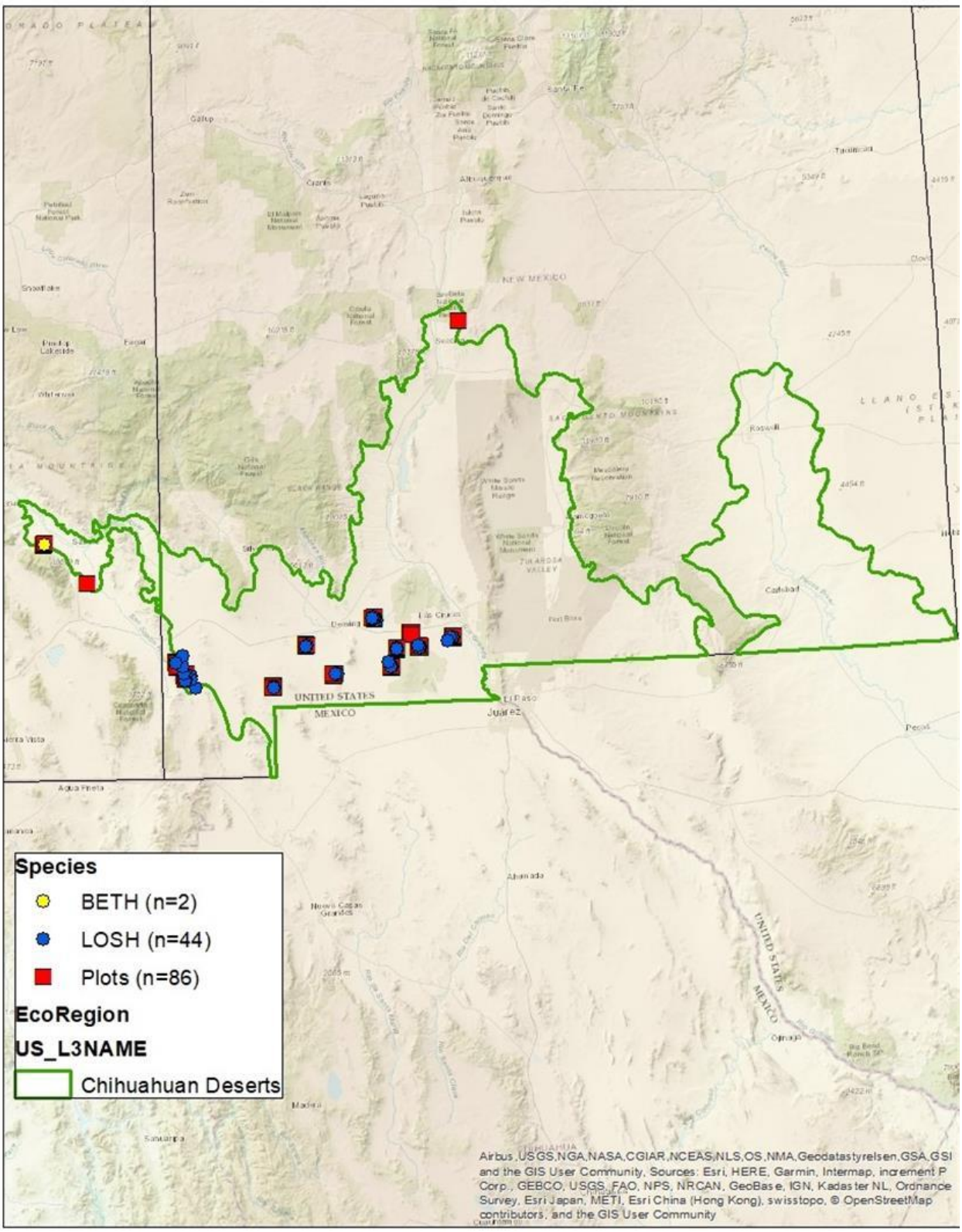

Figure 10. Plots surveyed and species detected during thrasher surveys in the Chihuahuan Desert ecoregion, 2017-2018. BETH = Bendire's Thrasher, LOSH = Loggerhead Shrike.

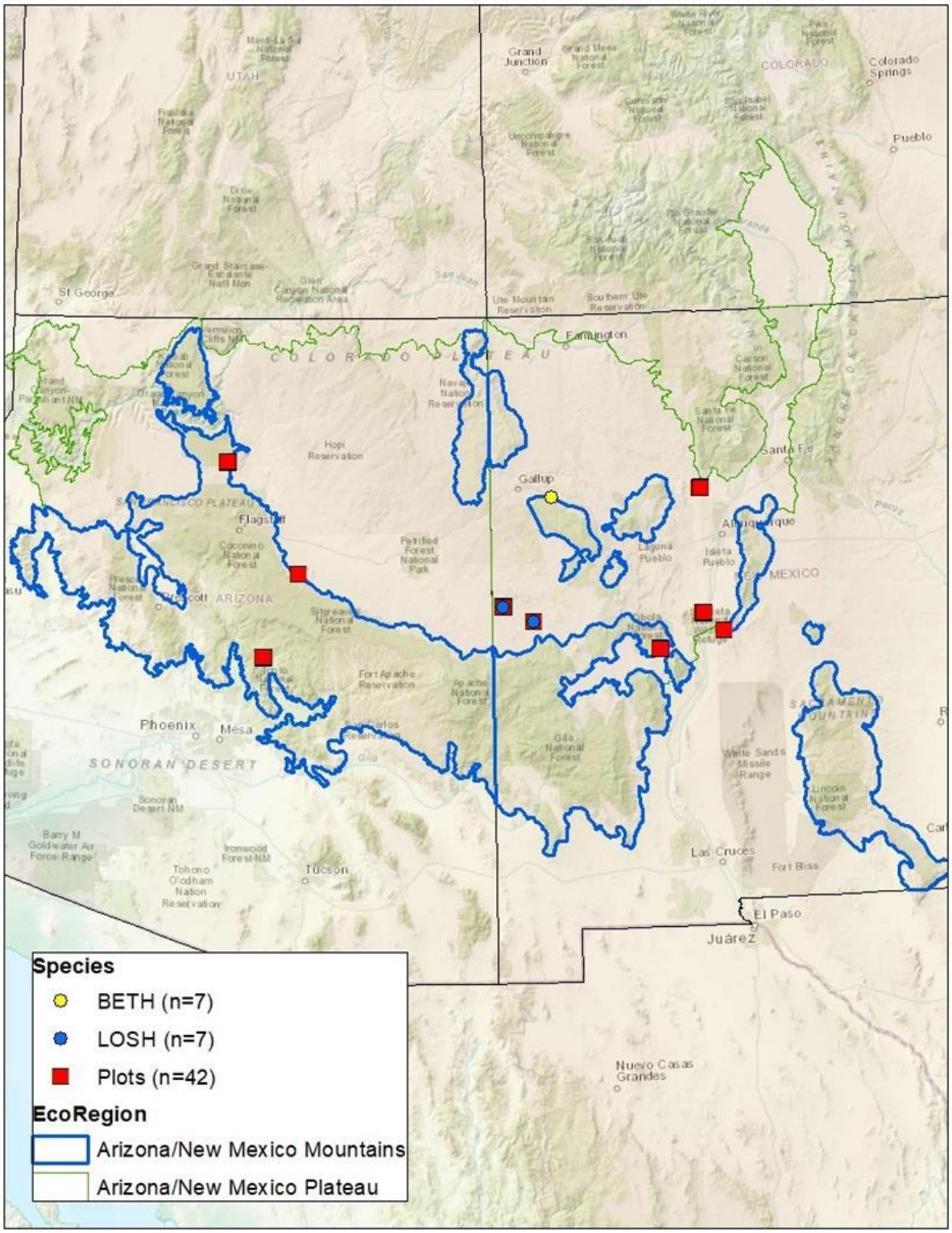

Figure 11. Plots surveyed and species detected during thrasher surveys in the Arizona/New Mexico Mountains and Arizona/New Mexico Plateau ecoregion, 2017-2018. BETH = Bendire's Thrasher, LOSH = Loggerhead Shrike.

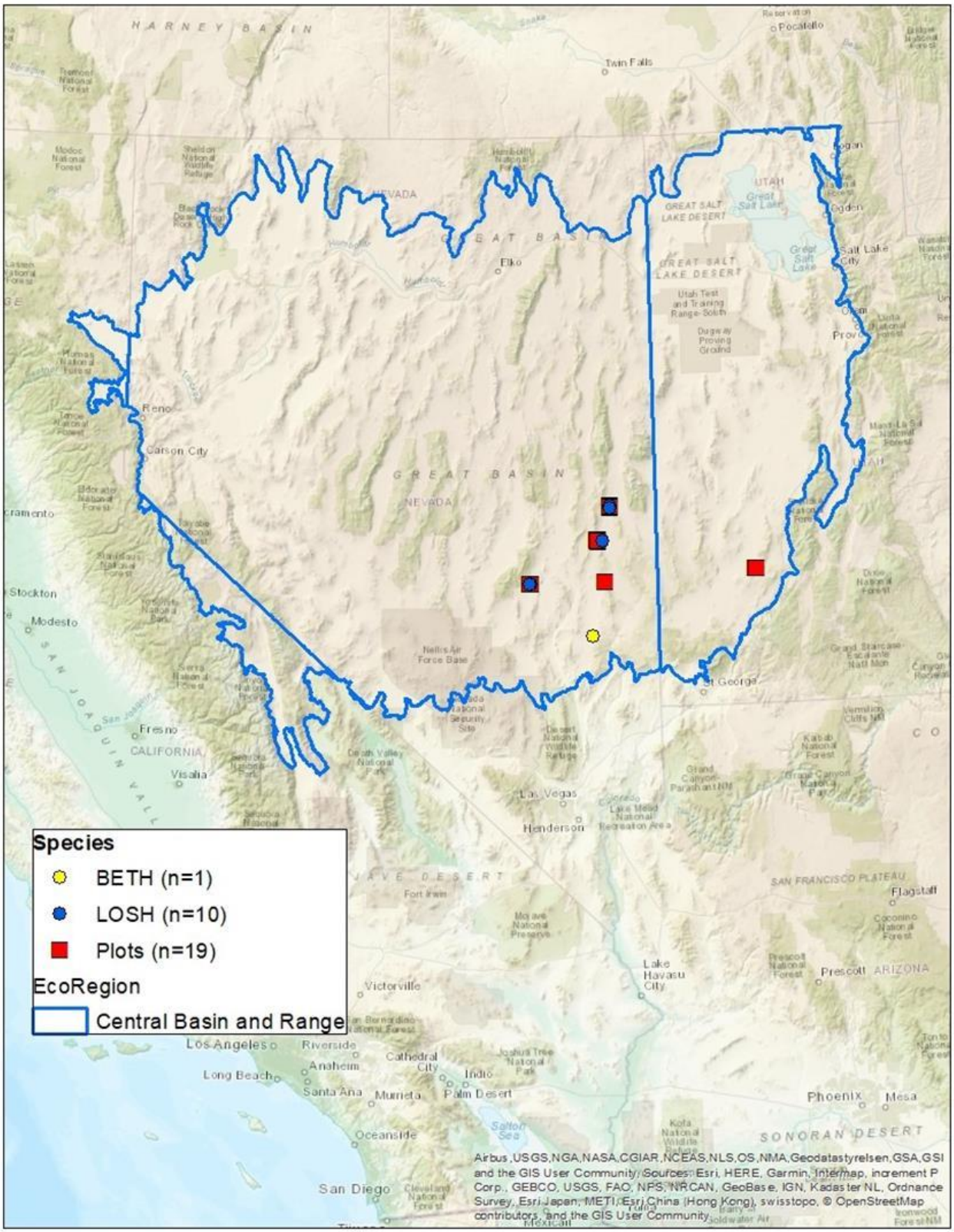

Figure 12. Plots surveyed and species detected during thrasher surveys in the Central Basin and Range ecoregion, 2017-2018. BETH = Bendire's Thrasher, LOSH = Loggerhead Shrike.

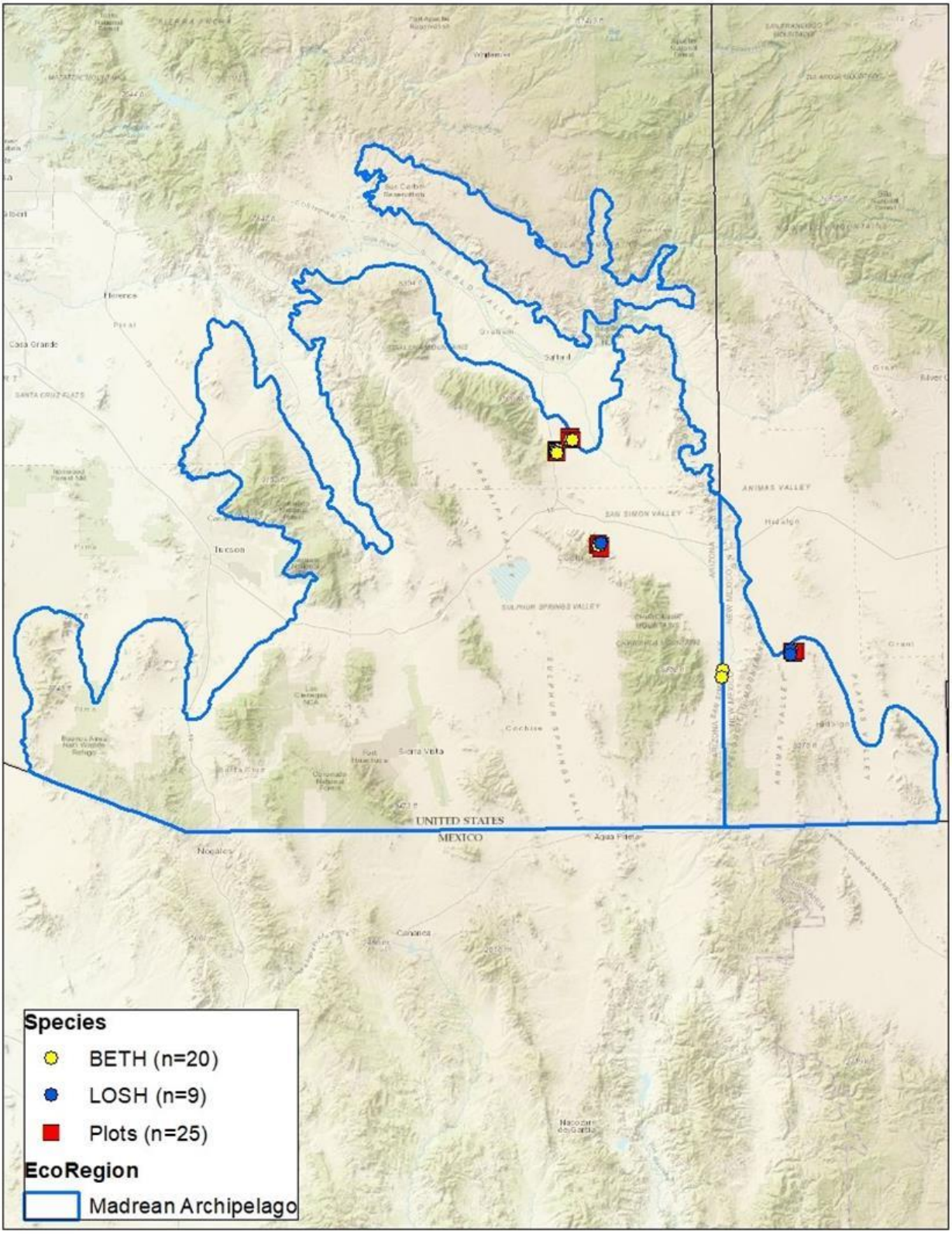

Figure 13. Plots surveyed and species detected during thrasher surveys in the Madrean Archipelago ecoregion, 2017-2018. BETH = Bendire's Thrasher, LOSH = Loggerhead Shrike.

Thrasher Habitat Use

Thrasher Nesting Substrates

During the 2017 and 2018 surveys, several nests of both thrasher species were located, and the plant species providing the substrate was recorded. Both thrasher species nest off the ground, often in spiny or spiky vegetation (Tables 6 and 7). A total of 16 Bendire's Thrasher nests were found, six of which were located in Joshua trees (*Yucca brevifolia*), six in cholla cactus (genus *Cylindropuntia*), and the remainder in other plants (Figure 14). The majority of the 84 LeConte's Thrasher nests found were located in *Cylindropuntia* cactuses (n = 43), particularly in buckhorn cholla (*Cylindropuntia acanthocarpa*) (n = 27; Figure 15). The remainder of the nests were mostly in Mojave Yucca (*Yucca schidigera*, n = 13), catclaw acacia (*Senegalia greggii*, n = 10), and wolfberry (*Lycium* sp., n = 9). The average nest heights and average heights of nest substrate plants are listed in Tables 6 and 7 for each species.

Table 6. Nest heights for each of the two thrasher species.

Species	Average Nest Height	Minimum Nest Height	Maximum Nest Height	Coefficient of Variation
Bendire's Thrasher	1.3 m (4.4 ft)	0.7 m (2.3 ft)	2 m (6.6 ft)	30%
LeConte's Thrasher	0.9 m (3.2 ft)	0.2 m (0.6 ft)	2.7 m (8.9 ft)	46%

Table 7. Nest substrate plant heights for each of the two thrasher species.

Species	Average Plant Height	Coefficient of Variation
Bendire's Thrasher	2.5 m (8.3 ft)	36%
LeConte's Thrasher	1.7 m (5.5 ft)	47%

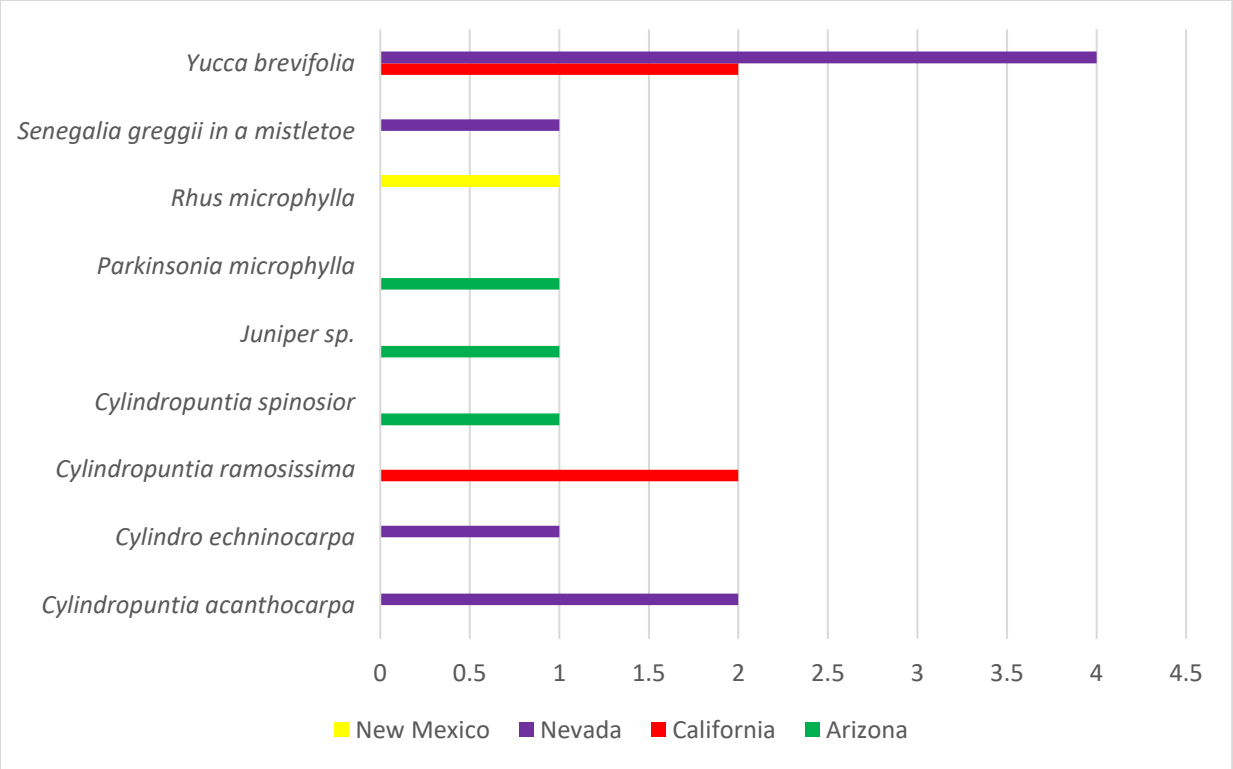

Figure 14. Plant species serving as nesting substrates of Bendire's Thrasher (n = 16).

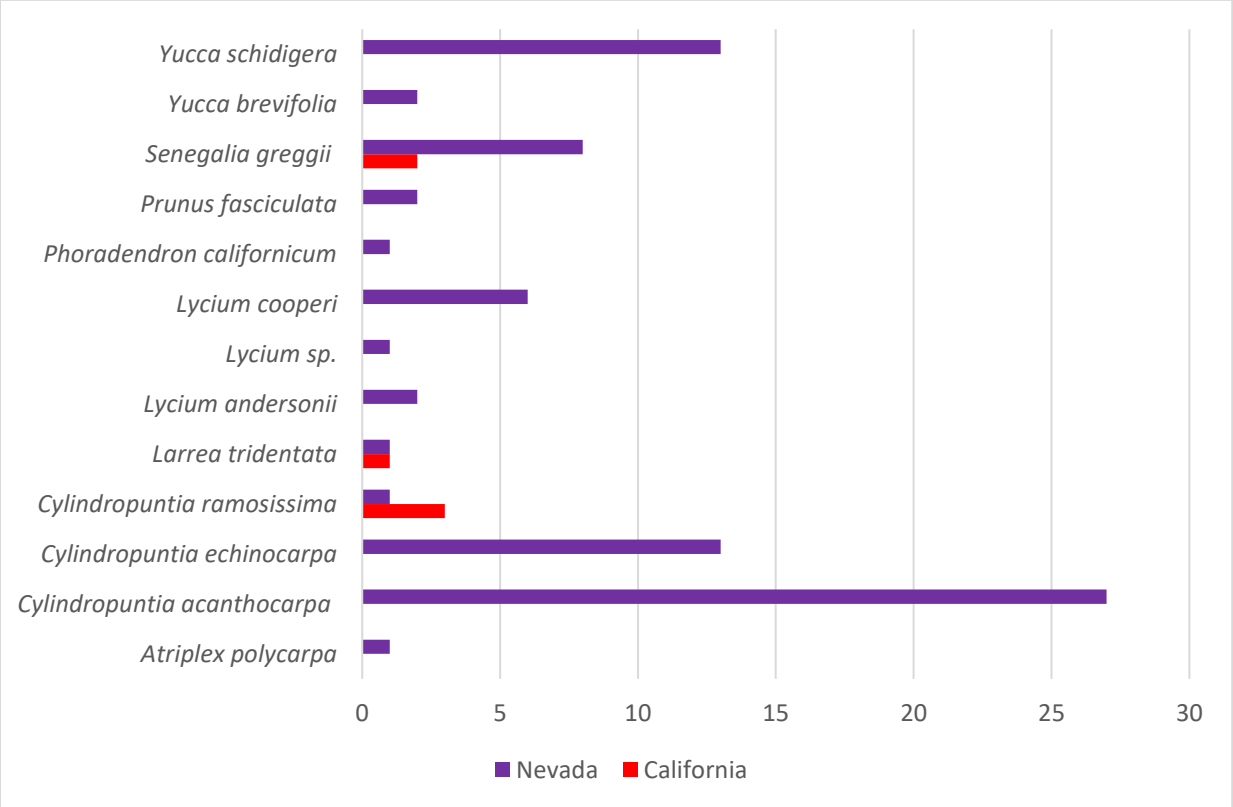

Figure 15. Plant species serving as nesting substrates of LeConte's Thrasher (n = 84).

Characteristics of Occupied Plots

Based on the vegetation assessments from thrasher-occupied plots, we constructed species-habitat profiles derived from the environmental variables assessed in each of these plots (Tables 6 – 9). This was done as a first step in assembling habitat suitability profiles for each of the thrasher species that may, in the future, be cross-walked to land use planning and management.

Table 8. Continuous environmental variables associated with Bendire's Thrasher occupancy region-wide (n = 80).

Habitat Variable	Average (metric)	Average (imperial)	Coefficient of Variation
Elevation	1,139 m	3,735 ft	31%
Cholla density	122 plants/ha	49 plants/ac	226%
Yucca density	60 plants/ha	24 plants/ac	206%
Small shrub density	4,552 plants/ha	1,842 plants/ac	142%
Large shrub density	1,255 plants/ha	508 plants/ac	109%
Tree density	53 plants/ha	22 plants/ac	216%
Fruit-bearing shrub density	22 plants/ha	9 plants/ac	180%
Mistletoe density	3.7 plants/ha	1.5 plants/ac	329%
% Invasive plant cover	4.5%	4.5%	159%
% Wash cover (within survey plot)	13%	13%	103%
Slope (degrees)	2.17	2.17	193%
Aspect (degrees)	170	170	63%

Table 9. Categorical environmental variables associated with Bendire's Thrasher occupancy region-wide (n = 80).

Habitat Variable	Plots Without	Plots With
Presence of Livestock Use	47%	53%
Presence of OHV Use	74%	26%
Presence of Invasive Plants	22%	77%

Table 10. Continuous environmental variables associated with LeConte's Thrasher occupancy region-wide (n = 151).

Habitat Variable	Average (metric)	Average (imperial)	Coefficient of Variation
Elevation	939 m	3,081 ft	16%
Cholla density	26 plants/ha	10 plants/ac	252%
Yucca density	26 plants/ha	10 plants/ac	199%

Habitat Variable	Average (metric)	Average (imperial)	Coefficient of Variation
Small shrub density	3,945 plants/ha	1,597 plants/ac	90%
Large shrub density	1348 plants/ha	545 plants/ac	113%
Tree density	10 plants/ha	4 plants/ac	286%
Fruit-bearing shrub density	22 plants/ha	9 plants/ac	197%
Mistletoe density	4 plants/ha	1.6 plants/ac	258%
% Invasive plant cover	0.07%	0.07%	7,243%
% Wash cover (within survey plot)	13%	13%	113%
Slope (degrees)	1.83	1.83	108%
Aspect (degrees)	178	178	50%

Table 11. Categorical environmental variables associated with LeConte's Thrasher occupancy region-wide (n = 151).

Habitat Variable	Plots Without	Plots With
Presence of Livestock Use	92%	8%
Presence of OHV Use	55%	45%
Presence of Invasive Plants	7%	93%

Habitat Analyses Based on Vegetation Assessments of Survey Plots

Field vegetation assessments were completed on 870 plots with and without thrasher detections, as well as an additional 19 locations with incidental Bendire's Thrasher detections. Variables used in logistic regression models to predict presence and absence of thrashers on plots included densities of cholla, yucca, shrubs, trees, and shrub/trees; counts of mistletoe clumps and counts of all fruit-bearing shrubs; percent cover of wash vegetation and percent cover of invasive species; the presence/absence of livestock and off-highway vehicle (OHV) use; and elevation, slope, and aspect of the site.

Bendire's Thrasher

Bendire's Thrashers were found in 80 of 839 plots region-wide (9.5 percent), i.e., throughout the 2017 and 2018 study area. The final logistic regression model retained cholla and tree densities and their quadratic terms, wash cover, presence of livestock, and elevation (Table 12, Figures 16 – 20). This model explained 12.8 percent of the overall variance relative to an intercept-only null model. Specifically, cholla densities of 50 plants/ha or higher appear to increase the probability of Bendire's Thrasher occupancy (Figure 16), as do tree densities between 1 and 500 plants/ha (Figure 17), the presence of a wash in the plot (slight effect, Figure 18), presence of livestock (slight effect, Figure 19), and increasing elevation (Figure 20).

Table 12. Statistical model results for Bendire's Thrashers. Estimates and Standard Errors (SE) are only included for terms retained in the final model and are on the logistic scale.

Term	Estimate	SE (Estimate)	P value
Intercept	-3.023	0.264	< 0.001
Cholla			0.270
Cholla^2	0.376	0.114	< 0.001
Yucca			0.231
Yucca^2			0.097
Shrub			0.938
Shrub^2			0.866
Shrub-Tree			0.635
Shrub-Tree^2			0.661
Tree	0.769	0.303	0.011
Tree^2	-0.774	0.303	0.011
Mistletoe			0.598
Mistletoe^2			0.569
Fruit Shrub			0.892
Fruit Shrub^2			0.113
Invasive			0.787
Invasive^2			0.254
Wash	0.494	0.167	0.003
Wash^2			0.964
Presence of livestock	0.637	0.284	0.025
Presence of OHV use			0.127
Slope			0.807
Aspect			0.434
Elevation	0.372	0.372	0.007
Elevation^2			0.853

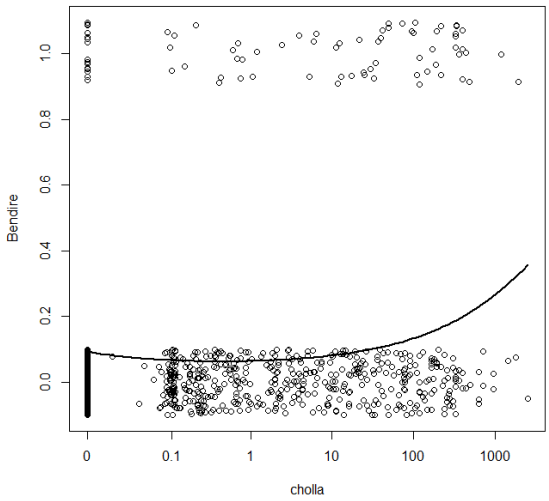

Figure 16. Fitted relationship (line) between cholla density and the presence of Bendire's Thrasher on the plot, with the other predictors held at their median value and livestock absent. Input data for the analysis (dots) are jittered along the y-axis values of "0" (bird absences) and "1" (bird presences) to show overlap.

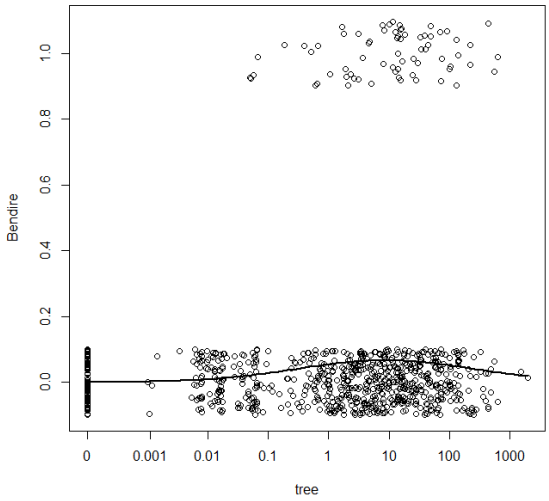

Figure 17. Fitted relationship (line) between tree density and the presence of Bendire's Thrasher on the plot, with the other predictors held at their median value and livestock absent. Input data for the analysis (dots) are jittered along the y-axis values of "0" (bird absences) and "1" (bird presences) to show overlap.

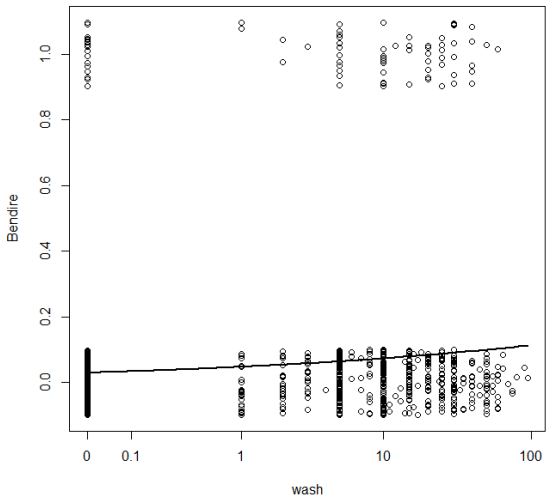

Figure 18. Fitted relationship (line) between wash cover and the presence of Bendire's Thrasher on the plot, with the other predictors held at their median value and livestock absent. Input data for the analysis (dots) are jittered along the y-axis values of "0" (bird absences) and "1" (bird presences) to show overlap.

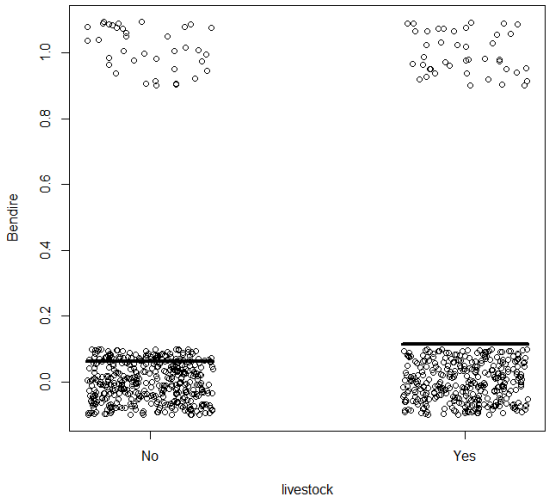

Figure 19. Fitted relationship (line) between livestock presence and the presence of Bendire's Thrashers on the plot, with the other predictors held at their median value. Input data for the analysis (dots) are jittered along the y-axis values of "0" (bird absences) and "1" (bird presences) to show overlap.

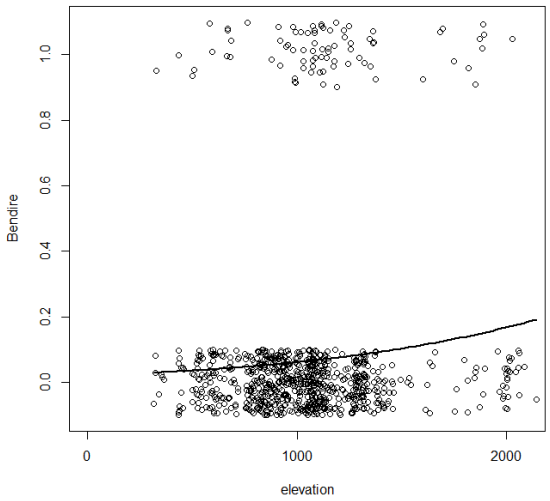

Figure 20. Fitted relationship (line) between elevation and the presence of Bendire's Thrashers on the plot, with the other predictors held at their median value and livestock absent. Input data for the analysis (dots) are jittered along the y-axis values of "0" (bird absences) and "1" (bird presences) to show overlap.

LeConte's Thrasher

LeConte's Thrashers were found in 151 of a total of 728 plots region-wide (20.1 percent). The final logistic regression model retained yucca and tree densities (linear and quadratic terms); fruit-bearing shrub counts (quadratic term only); invasive plant cover (linear and quadratic terms); and the presence/absence of livestock and OHV use (Table 13, Figures 21 – 26). The model explained 37.5 percent of the overall variance relative to an intercept-only null model. Specifically, yucca densities up to approximately 100 plants/ha appeared to increase the probability of LeConte's Thrasher with increasing yucca density, but higher yucca densities decrease the probability of LeConte's Thrasher occupancy (Figure 21). Similarly, low tree densities (1 – 10 trees/ha), low fruit-bearing shrub/tree densities, and low invasive plant densities increase the probability of occupancy, while higher tree, fruit-bearing shrub/tree, and invasive plant densities decrease it (Figures 22 – 24). Finally, the presence of livestock decreases the probability of LeConte's Thrasher occupancy (Figure 25), while the presence of OHV use appears to increase it (Figure 26).

Table 13. Statistical model results for LeConte's Thrashers. Estimates and Standard Errors (SE) are only included for terms retained in the final model and are on the logistic scale.

Term	Estimate	SE (Estimate)	P value
Intercept	0.718	0.478	0.134
Cholla			0.181
Cholla^2			0.397

Term	Estimate	SE (Estimate)	P value
Yucca	0.858	0.213	< 0.001
Yucca^2	-0.619	0.310	0.0453
Shrub			0.093
Shrub^2			0.234
Shrub-Tree			0.132
Shrub-Tree^2			0.115
Tree	-1.0426	0.282	< 0.001
Tree^2	-0.602	0.182	< 0.001
Mistletoe			0.441
Mistletoe^2			0.271
Fruit Shrub			0.085
Fruit Shrub^2	-0.602	0.281	0.032
Invasive plants	0.572	0.243	0.018
Invasive plants^2	-1.012	0.293	< 0.001
Wash cover			0.623
Wash cover^2			0.604
Presence of livestock	-1.871	0.466	< 0.001
Presence of OHV use	0.853	0.354	0.016
Slope			0.111
Aspect			0.556
Elevation			0.229
Elevation^2			0.872

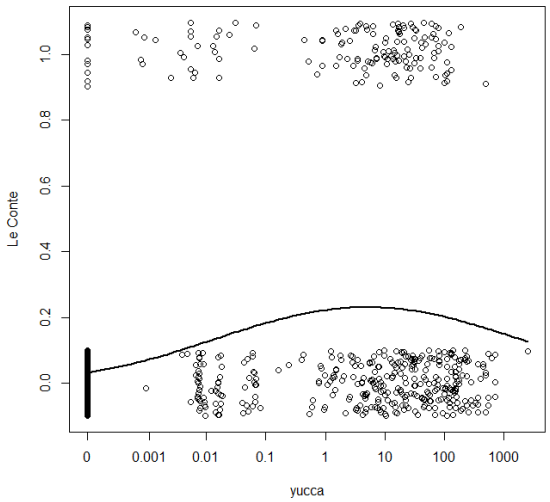

Figure 21. Fitted relationship (line) between Yucca density and the presence of LeConte's Thrashers on the plot, with the other predictors held at their median value and livestock and OHV use absent. Input data for the analysis (dots) are jittered along the y-axis values of "0" (bird absences) and "1" (bird presences) to show overlap.

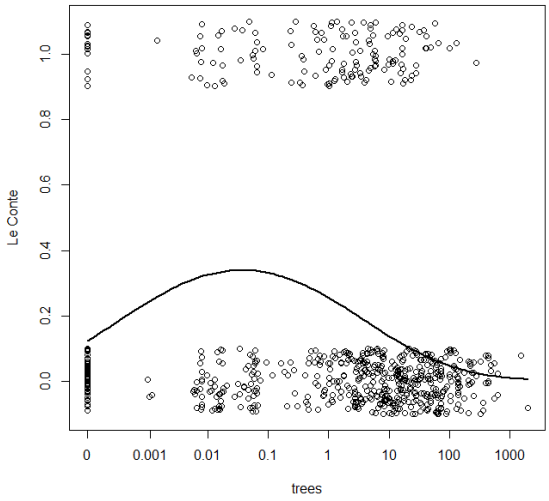

Figure 22. Fitted relationship (line) between tree density and the presence of LeConte's Thrashers on the plot, with the other predictors held at their median value and livestock and OHV use absent. Input data for the analysis (dots) are jittered along the y-axis values of "0" (bird absences) and "1" (bird presences) to show overlap.

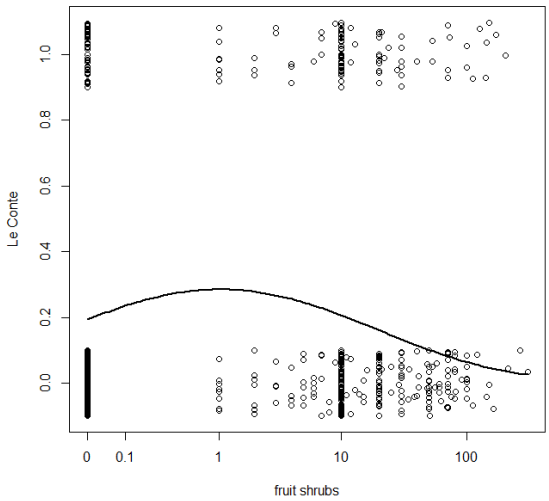

Figure 23. Fitted relationship (line) between fruit-bearing shrub density and the presence of LeConte's Thrashers on the plot, with the other predictors held at their median value and livestock and OHV use absent. Input data for the analysis (dots) are jittered along the y-axis values of "0" (bird absences) and "1" (bird presences) to show overlap.

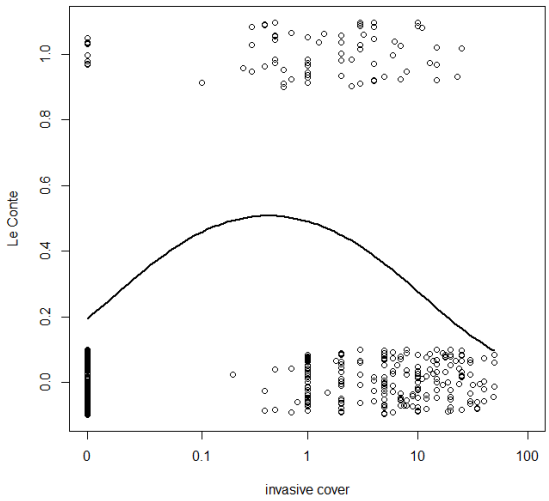

Figure 24. Fitted relationship (line) between invasive plant cover and the presence of LeConte's Thrashers on the plot, with the other predictors held at their median value and livestock and OHV use absent. Input data for the analysis (dots) are jittered along the y-axis values of "0" (bird absences) and "1" (bird presences) to show overlap.

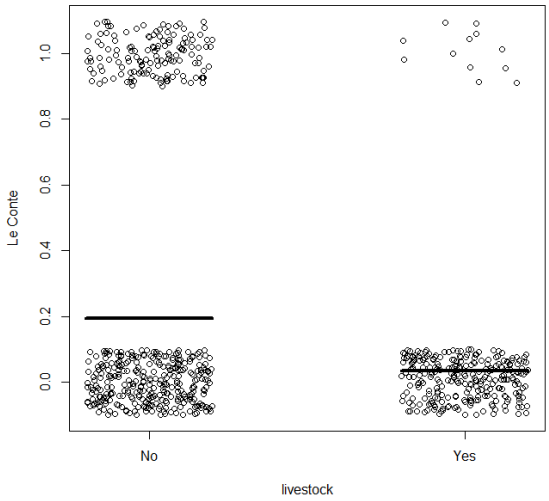

Figure 25. Fitted relationship (line) between livestock presence and the presence of LeConte's Thrashers on the plot, with the other predictors held at their median value and OHV use absent. Input data for the analysis (dots) are jittered along the y-axis values of "0" (bird absences) and "1" (bird presences) to show overlap.

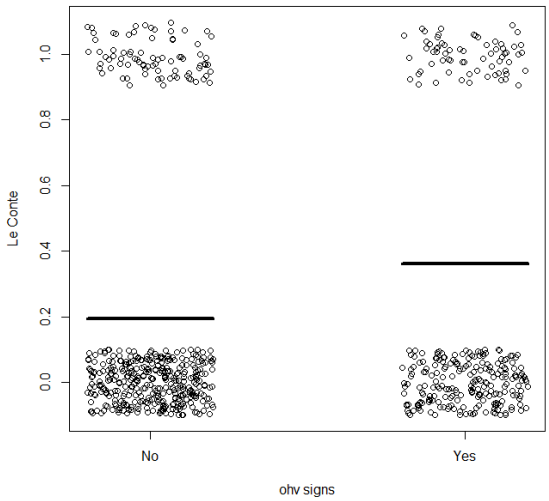

Figure 26. Fitted relationship (line) between OHV use presence and the presence of LeConte's Thrashers on the plot, with the other predictors held at their median value and livestock absent. Input data for the analysis (dots) are jittered along the y-axis values of "0" (bird absences) and "1" (bird presences) to show overlap.

Spatial Model Performance

We performed logistic regressions to examine the actual performance of the 2018 Maxent models in predicting the presence of Bendire's and LeConte's thrashers to explore whether the models can be refined to be useful for land management applications. Using the models' suitability values as a continuous variable, we found a significant positive correlation between the model's suitability index and presence of both Bendire's Thrasher (Figure 27, Table 14) and LeConte's Thrasher (Figure 28, Table 15). Figures 27 and 28 also show that the suitability values predicted for occupied plots for each of the thrashers fall into a narrower range than those predicted for unoccupied plots despite the fact that unoccupied plots were more numerous in both species. However, logistic regressions performed on the ranked categorical suitability variable, where the continuous suitability variable was divided into four suitability ranks (no, low, medium, and high), were mostly unable to predict presence of the thrashers, although the lowest suitability ranks performed well in LeConte's Thrasher (Tables 16 and 17). This analysis indicates that the models performed well inherently, but that their output suitability values cannot be simplified into categories without compromising their predictive value.

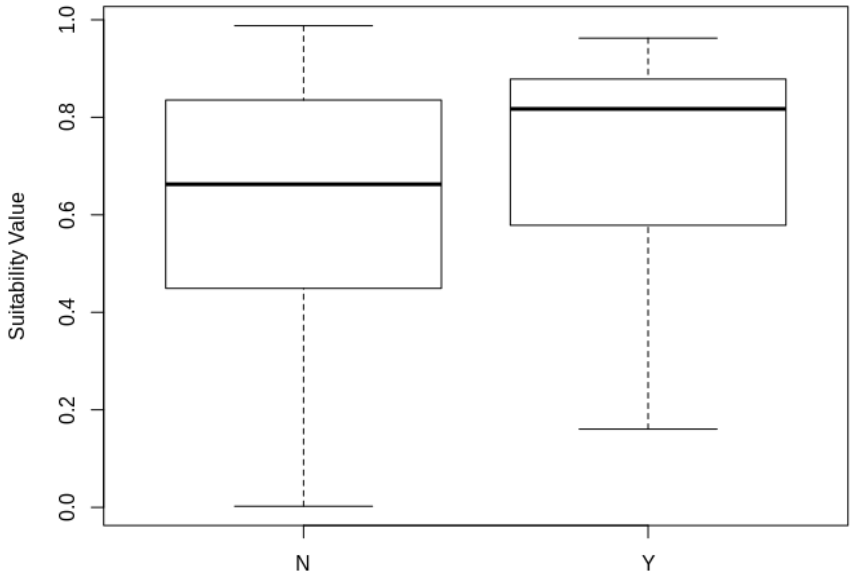

Figure 27. The 2018 Maxent model's predicted continuous suitability values for plots not occupied (N) and occupied (Y) by Bendire's Thrasher.

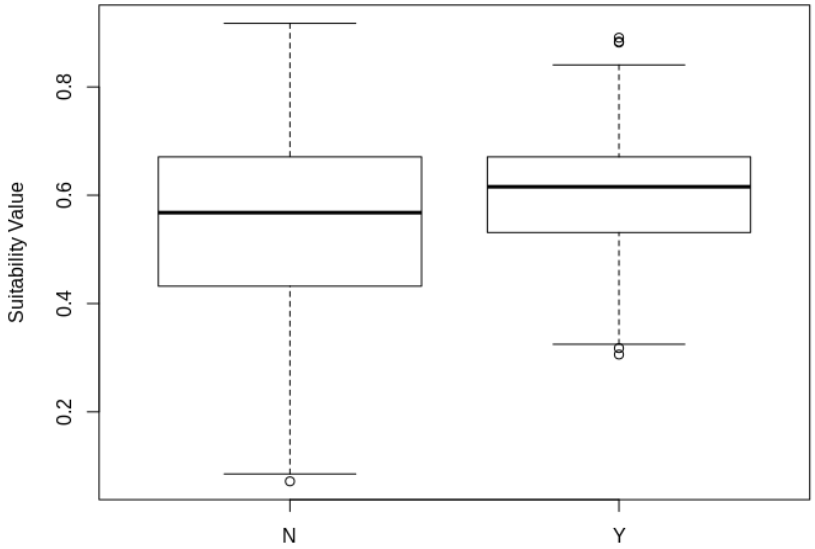

Figure 28. The 2018 Maxent model's predicted continuous suitability values for plots not occupied (N) and occupied (Y) by LeConte's Thrasher.

Table 14. Results from logistic regression analysis for Bendire's Thrasher using the 2018 Maxent model's suitability values as a continuous variable, and including the effect of each state as categorical variables.

Variables	Estimate	Std. Error	Z value	Pr(>|z|)
Intercept	-3.1943	0.611	-5.228	0.000000172
Model Value	1.9471	0.6923	2.812	0.004918
StateCA	0.1355	0.3876	0.35	0.726702
StateNM	-1.5309	0.6657	-2.3	0.021471
StateNV	-1.4601	0.3846	-3.796	0.000147
StateUT	-15.4378	799.4669	-0.019	0.984594
MigratoryBETHYes	0.1867	0.4439	0.421	0.674033

Table 15. Results from logistic regression analysis for LeConte's Thrasher using the 2018 Maxent model's suitability values as a continuous variable, and including the effect of each state as categorical variables.

Variable	Estimate	Std. Error	Z value	Pr(>|z|)
Intercept	-20.6826	708.1589	-0.029	0.977
Model Value	3.3928	0.6631	5.117	3.11e-07
StateCA	17.0199	708.1588	0.024	0.981
StateNV	18.1587	708.1588	0.026	0.98

Table 16. Results from logistic regression analysis for Bendire's Thrasher using the 2018 Maxent model's ranked suitability categories as categorical variables, and including the effect of each state as categorical variable.

Variable	Estimate	Std. Error	z value	Pr(>|z|)
Intercept	-2.1953	0.4521	-4.856	1.20e-06
high suitability	0.6778	0.3806	1.781	0.0749
low suitability	-0.5731	0.5627	-1.018	0.3085
no suitability	0.3882	0.4218	0.92	0.3574
StateCA	0.124	0.3898	0.318	0.7504
StateNM	-1.5157	0.6631	-2.286	0.0223
StateNV	-1.5371	0.3798	-4.047	5.18e-05
StateUT	-15.517	798.7911	-0.019	0.9845
MigratoryBETHYes	0.2529	0.4368	0.579	0.5626

Table 17. Results from logistic regression analysis for LeConte's Thrasher using the 2018 Maxent model's ranked suitability categories as categorical variables, and including the effect of each state as categorical variable.

Variable	Estimate	Std. Error	Zvalue	Pr(>|z|)
Intercept	-18.7133	682.445	-0.027	0.9781

Variable	Estimate	Std. Error	Zvalue	Pr(>|z|)
high suitability	-0.2108	0.6199	-0.34	0.7338
low suitability	-1.5496	0.3106	-4.988	6.09e-07
no suitability	0.5104	0.2499	2.043	0.0411
StateCA	17.2575	682.445	0.025	0.9798
StateNV	18.3276	682.4449	0.027	0.9786

Discussion

The primary short-term goals of this two-year project were for the DTWG to develop a robust and standardized inventory and monitoring protocol for desert thrashers, to explore habitat associations of the two species that are relevant to land management, and to form a five-state partnership of stakeholders focused on the conservation and science of desert thrashers. All three of these elements are critical in developing more effective conservation strategies for these rapidly declining species.

The protocol developed for thrashers has the following advantages: (1) prescribed surveys occur during the peak breeding season of the two thrasher species, which is earlier than national landbird monitoring protocols prescribe, such as the BBS; (2) area searches, unlike point counts, allow surveyors to actively search and thus increase the probabilities of detection and finding nesting evidence for these cryptic species; and (3) a moderately rapid area search allows the completion of three or more surveys in one morning, which is an advantage when surveying species that are scarcely distributed across the landscape. Over the two years of implementation (2017 and 2018), the protocol was optimized by allowing for assessing habitat use of incidentally-detected thrashers and refining the spatial models used for defining and stratifying the study area. The initial evaluation of habitat use by the two species was done using these field vegetation assessments to describe region-wide averages of key habitat variables for plots occupied by each of the species. These habitat evaluations begin to inform land managers about the landscapes, vegetation cover types, and land uses of currently occupied thrasher breeding areas. Further, statistical models using plots with and without thrasher detections illuminated the vegetation variables that appear to drive thrasher breeding occupancy region-wide.

Specifically, field vegetation assessments indicated that Bendire's Thrashers are more likely to be found in areas with high cholla densities, near washes, in areas with low topographic relief (low slopes), in areas with trees present but in low density, and elevations on average around 1,000 meters. They are also likely to be found in areas where livestock is also present. LeConte's Thrashers are more likely to be found breeding in areas that have yucca, trees, fruit-bearing shrubs/trees, and invasive plant cover. All of these plant density variables were selected by LeConte's Thrashers in the moderate density range, with likelihood of thrasher occupancy dropping off at very low densities and very high densities. Further, LeConte's Thrashers were

more likely to be found in areas with evidence of OHV disturbance, in areas with low topographic relief (low slopes), and in elevations around 900 meters.

It is important to note that, while these habitat relationships were identified as important correlates of thrasher occupancy, not all of them necessarily describe a habitat preference as such. For instance, OHV uses may be related to locally available scenic values and low slopes, which may happen to coincide with vegetation and soil covers selected by thrashers. Therefore, additional thrasher and land use data need to be obtained and analyzed to narrow down specific habitat elements required by thrashers and the potential conservation threats to these elements. The performance analyses of the spatial habitat suitability models for the two species indicate that, even with low sample sizes, the models appear to be reasonably robust in predicting thrasher occupancy when suitability is used as a continuous variable. This provides reason to expect that further improvements to the spatial models can help pinpoint specific landscape variables that matter to occupancy, and thus to conservation, of both thrashers.

While both the spatial habitat suitability models and the statistical models based on field assessments produced valuable insights for land management, the two-year survey effort also brought to light ecoregional effects that may play a role in thrasher habitat use and probability of breeding occupancy. The ecoregional difference in thrasher occupancy led the DTWG to compile descriptions of the habitat types used by thrashers in three ecoregions (Mojave, Sonoran, and Chihuahuan ecoregions) to evaluate whether or not a region-wide approach in landscape and habitat use is appropriate for these species.

Habitat Descriptions by Region

Mojave Basin and Range Ecoregion

Bendire's Thrasher

In the Mojave Desert, the Bendire's Thrasher is most often found in areas containing moderate density of Joshua tree (*Yucca brevifolia*), as well as big galleta (*Hilaria rigida*) or other bunchgrass species (Figure 29). Smaller shrubs are typically present in moderate to high density and include a diversity of species such as Mojave buckwheat (*Eriogonum fasciculatum*), blackbrush (*Coleogyne ramosissima*), white bursage (*Ambrosia dumosa*), ephedra (*Ephedra* sp.), and winterfat (*Krascheninnikovia lanata*). Other yucca species (*Y. schidigera* and/or *Y. baccata*) and large to medium-size chollas (*Cylindropuntia acanthocarpa* and/or *C. echinocarpa*) are usually present in medium to high densities. Occasionally, the Bendire's Thrasher is found in areas lacking Joshua tree when large Mojave yuccas (*Yucca schidigera*) are present.

Figure 29. Typical Mojave Basin and Range Bendire's Thrasher habitat. Photo by Dawn Fletcher.

LeConte's Thrasher

In the Mojave Desert, the LeConte's Thrasher is most often found in areas of little topographic relief. This species is most often associated with the creosote-white bursage cover types which make up the majority of the Mojave Desert (Figure 30). Within this habitat type, it is typically found in areas containing at least one of the following species: Mojave yucca (*Yucca schidigera*), silver cholla (*Cylindropuntia echinocarpa*), or buckhorn cholla (*Cylindropuntia acanthocarpa*) (Fletcher 2009). This species can also be found in desert washes or arroyos containing desert willow (*Chilopsis linearis*) or catclaw acacia (*Senegalia greggii*). Additionally, the LeConte's Thrasher can be found nesting in saltbush-dominated cover types, specifically in cattle saltbush (*Atriplex polycarpa*) (Fletcher 2009, Sheppard 2018).

Figure 30. Typical Mojave Basin and Range LeConte's Thrasher habitat. Photo by Dawn Fletcher.

Sonoran Basin and Range Ecoregion

Bendire's Thrasher

Breeding and wintering populations (both migratory and resident) of Bendire's Thrashers occur in the flood plains and valleys within parts of the Sonoran Basin and Range Ecoregion, including the Lower Colorado/Lower Gila River valleys, Middle Gila/Salt River floodplains, Gila/Salt River Intermediate basins, Upper Gila River Basin, Central Sonoran/Colorado Desert Basins and Arizona Upland/Eastern Sonoran basins. In altered habitats, Bendire's Thrashers (resident and migratory populations) can be commonly found utilizing mesquite tree and shrub-lined edges of agricultural fields and large livestock operations within the Sonoran ecoregion, as well as small rural farm and ranch communities found in these areas (Figure 31).

The vegetation community in the Sonoran ecoregion where Bendire's Thrashers regularly occur is commonly composed of creosote bush (*Larrea tridentate*), wolfberry (*Lycium* spp.), graythorn (*Zizipus obtusifolia*), yucca (*Yucca* spp.), and cholla (*Cylindropuntia* spp.) as well as larger structures of cholla, yucca, or desert tree species such as mesquite (*Prosopis* spp.), palo verde (*Parkinsonia* spp.), or ironwood (*Olneya tesota*).

Figure 31. Views of Bendire's Thrasher habitat in the Sonoran Basin and Range ecoregion. Photos by Jennie MacFarland.

LeConte's Thrasher

While LeConte's Thrashers do occur in the Sonoran Desert, they were not surveyed during this project, so no habitat description is currently available. However, the photos from LeConte's Thrasher occupied habitat in the Sonoran desert indicate that the dominant tree species includes mesquite (*Prosopis* spp.) in moderate densities with a light understory of shrubs and grasses and various amounts of bare soil (Figure 32).

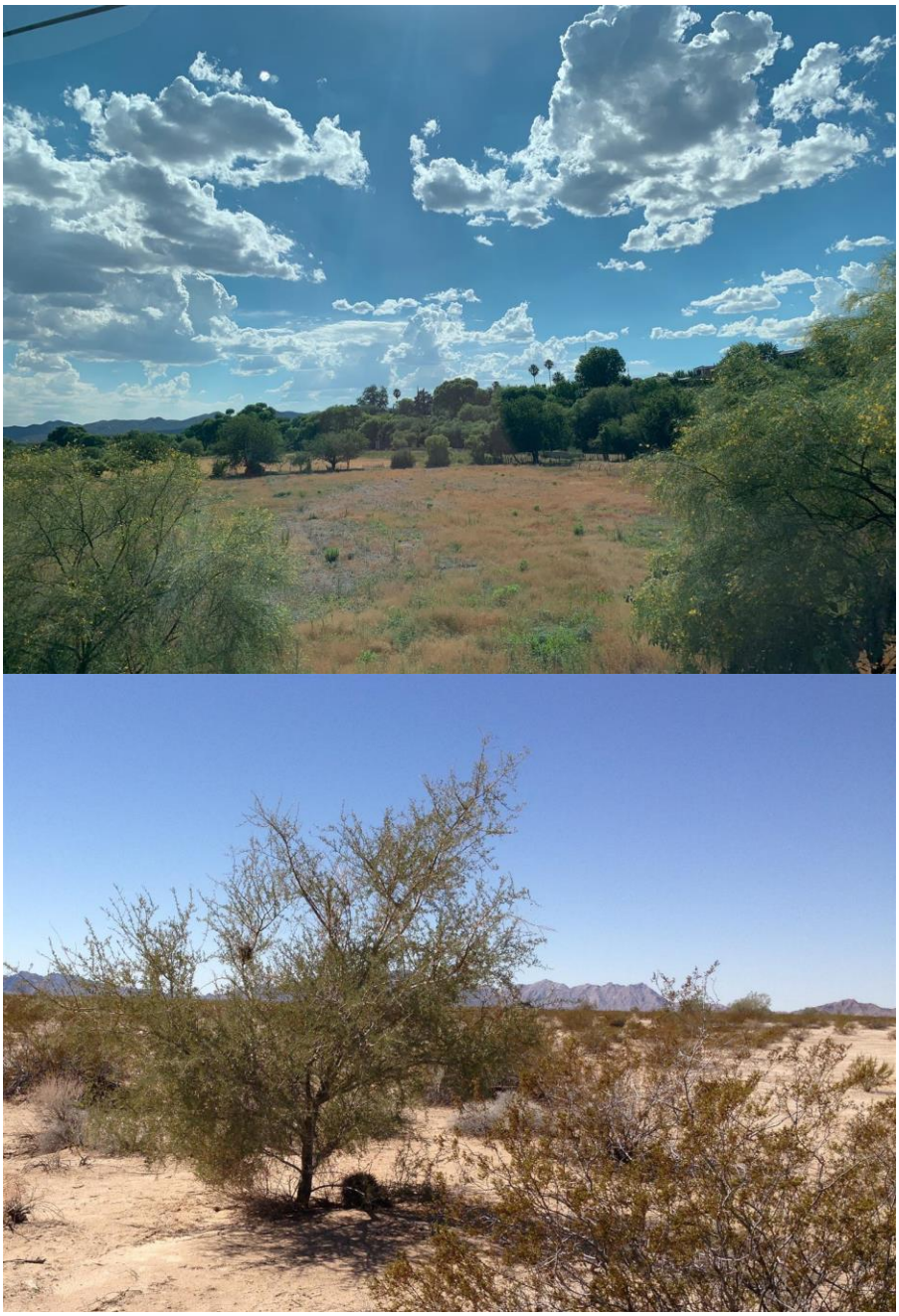

Figure 32. Views of LeConte's Thrasher habitat in the Sonoran Basin and Range ecoregion. Photos by Chrissy Kondrat.

Chihuahuan Desert Ecoregion

Bendire's Thrasher

While we only found Bendire's Thrashers on one plot in the Chihuahuan Desert during this project, previous work by New Mexico State University documented larger populations of this species in the ecoregion. In the Chihuahuan Desert, Bendire's Thrashers can be found in desert scrub and desert grassland habitat types (Figure 33), on generally flat slopes and elevations below 1,200 m. They are often found toward the bottom of bajada slopes, and in closed basins. Regardless of habitat type, average visual obstruction, amount of bare ground, and average shrub height were all positive drivers of Bendire's Thrasher occurrence within the Chihuahuan Desert. Areas with greater proportion of bare ground and taller than average shrubs were more likely to be occupied by Bendire's Thrashers. They are associated with shrubs such as soaptree yucca (*Yucca elata*), honey mequite (*Prosopis glandulosa*), little-leaf sumac (*Rhus microphylla*), catclaw acacia (*Senegalia greggii*) and creosote (*Larrea tridentata*). However, Bendire's Thrashers are not found in contiguous patches of dense creosote or mesquite; these patterns are known based on breeding Bendire's Thrasher research conducted by New Mexico State University. The LeConte's Thrashers does not occur in the Chihuahuan Desert ecoregiom.

Figure 33. Views of Bendire's Thrasher habitat in the Chihuahuan Desert. Photos by Corrie Borgman.

Conclusions and Future Direction

The two-year thrasher project was conducted throughout the Southwest to provide a major step forward in closing the gaps in knowledge on distribution, spatial abundance, and habitat suitability for Bendire's and LeConte's thrashers. The project also clarified how research and monitoring can further assist in land management decisions that affect the conservation of the two rapidly declining species. The protocol has been optimized for effective coverage of these difficult-to-monitor species and has laid the groundwork for a cost-effective and efficient monitoring strategy. The infrastructure for such a monitoring program has been established through the AKN's Borderlands Node (the Borderlands Avian Data Center), and the DTWG provides active coordination and the scientific and analytic skills to make the program successful. Medium- or long-term monitoring needs to be part of any conservation strategy for rapidly-declining species, as it is the only way to evaluate the effects of conservation actions and to determine when populations have stabilized or rebounded.

However, in the near-term, conservation strategies that lead to effective conservation action need to be developed using a scientific approach. The need for conservation action for the two thrashers is recognized by states and federal agencies that manage southwestern lands and wildlife (Appendix 1). Therefore, the next near-term objective of the program should be to refine our current knowledge of the two species' habitat suitability and landscape use to inform decisions in land management that may affect the species.

To move forward with the proposed near-term objective, the DTWG recommends that the next major step should entail the refinement of models based on current data. Originally, the spatial suitability modeling was only developed for optimizing the survey effort in the two-year project. However, by refining the existing models through a multi-model averaging approach which includes recent thrasher data and making use of additional land use and vegetation layers, a land-management applicable habitat suitability map can be created. The most critical revision in the modeling, based on observed differences between ecoregions (see also above summaries), is to introduce "ecoregion" as a covariate into the spatial models. Considering ecoregions will allow the models to tease out habitat suitability at an ecoregional scale rather than the current region-wide scale of all ecoregions. Additional future work designed to build on the two-year project includes the following recommendations from the DTWG:

- Enhancing current thrasher data sets with additional covariates that might be useful for modeling thrasher occurrence and should thus be explored for analysis. These include:
    - A level three ecoregion attribute that could be used as a basis for ecoregion-specific data summaries and models,
    - Selected attributes derived from BLM Assessment / Inventory / Monitoring (AIM) landscape toolbox layers. More specifically, investigate how the AIM terrestrial data (which includes measures of vegetation and soil condition such as plant species cover and composition, plant height, and soil stability) correlates with

thrasher plots range wide, and with AZ Coordinated Bird Monitoring (CBM) plots (e.g., grasslands, Sonoran Desert).
    - Other attributes could be derived from BLM management layers (such as desert tortoise, burros, Regional Ecological Assessments) to investigate any possible correlations.
    - Recent thrasher data from Arizona and New Mexico theses and other local projects.

- Summarizing and mapping enhanced data sets to assist in model parameterization and interpretation.

- Rerunning logistical regression models (which previously relied solely on ground-derived assessment data) for each species using an ecoregional filter and incorporating additional attributes derived from AIM data.

- Analyzing correspondence of thrasher occurrence with BLM management actions, designations, and priorities as characterized by BLM management layers (see above) to determine how existing management paradigms and actions might either: a) serve as a synergistic framework for thrasher conservation measures, and/or b) determine the potential of existing management actions and plans to affect thrasher conservation.

- Redoing spatial analyses and spatially-explicit predictive models to: a) utilize enhanced occurrence data sets (see below) and predictors (see above), and b) improve upon the previously utilized Maxent framework including a multi-model or hierarchical modeling approaches that better accommodate data sets that tend to generate an excess of “false positive” occupancy predictions due to the distribution patterns of the target species.

- Gathering additional field data from under-surveyed sampling strata, and/or to serve as validation data for second-generation statistical and spatial predictive models.

- Including a method for estimating thrasher detectability in future survey efforts to allow for population size and density estimation.

- Exploring how the thrasher protocol could be integrated with other ongoing landbird monitoring programs (e.g., Pavlacky et al. 2017).

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Appendix 1. State Wildlife Action Plans' Priorities for Desert Thrashers

Summary of the desert thrashers as a SGCN in State Wildlife Action Plans of southwestern, including the basis for its inclusion (if given), actions identified, and page number references (AGFD 2012, WAPT 2012, CDFW 2015, UWAPJT 2015, NMDGF 2016):

Arizona

Arizona's 2012-2022 State Wildlife Action Plan identifies LeConte's Thrasher as a Tier 1B SGCN and Bendire's Thrasher as Tier 1C in Appendix E (pg. 209, 220) of the Plan. Of the 145 bird species that are currently considered SGCN in Arizona, only 20 species are monitored sufficiently to determine population trend (pg. 136). Both thrasher species are not monitored adequately.

LeConte's Thrasher is noted in the Plan under the lowland Sonoran Desertscrub section (pg. 33). Threats are listed for this unique habitat community, including livestock grazing and loss and fragmentation by urban expansion and energy development, especially on private and former State Trust Lands and in the vicinity of Yuma and Phoenix. Although animal and plant diversity is not as great as that of upland desert communities in the Sonoran Desert, many of the species that inhabit this region are not found elsewhere in the state including LeConte's Thrasher. Bendire's Thrashers are found in local and limited numbers in multiple habitats in Arizona, so are not specifically mentioned in the plan in the habitat sections.

California

A major component of the California State Wildlife Action Plan (CDFW 2015) is the identification of species of greatest conservation need (SGCN) in the State. The 2015 update to SWAP defined SGCNs to include all species of special concern (SSC) in addition to state listed species and those species particularly vulnerable to climate change. California Department of Fish and Wildlife updated the bird SSC list (BSSC; Shuford and Gardali 2008) and those are included as SGCN designates for the CDFW (2015) update (Appendix C: Table 1).

Both LeConte's Thrasher (LETH: Toxostoma lecontei), San Joaquin population only, and Bendire's Thrasher (BETH: Toxostoma bendirei) are considered SGCN species (CDFW 2015: Appendix C Table 1). In the previous two California Bird Species of Special Concern efforts the entire LETH population in California was considered a SSC (Remsen 1978, CDFG 1992).

BSSC s were ranked in Shuford and Gardali (2008) by an advisory committee used seven objective criteria for scoring and ranking nominee taxa: population trend, range trend, population size, range size, population concentration, percentage of entire range or population within California (endemism), and impact of threats. Ultimately, 283 taxa were nominated, of these 39 species and 24 subspecies or geographic populations were selected as BSSC using ranking criteria above. LETH San Joaquin population is one of 11 bird taxa currently considered a BSSC "(year round) priority 1" with "greatly reduced (>40–80%)" trends in both population and range. Population's size is less than 1000 individuals. BETH is currently "(breeding season) priority 3 (one of 25 bird taxa) with population trend slightly reduced (>10–20%) or suspected of having been reduced but trend unknown. Population size was also

less than 1000 and ≤10% of it's range in California is currently occupied. Both taxa/population received threats scores of 10 meaning "in the next 20 years, habitat loss, habitat degradation, or other human-induced threats are projected to moderately reduce (>10–15%) a taxon's population in California"'.

Sterling (2008; in Shuford and Gardali 2008) describes major threats for BETH as "housing and agricultural development especially in the West Mojave. He also suggests "military operations" on the many DOD bases in the BETH's range may "degrade or destroy thrasher habitat. "Other direct threat include the removal yuccas and cholla cacti and off-road vehicles during the breeding season". Extended drought and catastrophic fires are other known threats.

Fitton (2008) (in Shuford and Gardali 2008) states habitat loss and degradation continues to be a major population level threat to LETH with habitat conversion to agriculture being the single biggest factor. Fire is also a major threat that impacts salt plants favored by LETH and causes type-conversion to exotic annual grassland. Summer-long over grazing by cattle when shrubs are vulnerable is also know to convert shrubland to non-native annual grassland.

CDFW (2015) includes threat assessments for habitats that support SGCNs, and provides conservation goals and actions for these habitats. Both species are recognized as SGCN in the Desert Province and are the focus of the conservation strategies and will benefit from the actions taken to implement the conservation strategies (Table 5.6-3).

BETH is in the **Mojave Desert Unit** in the "Shadscale-Saltbush Scrub" conservation target as well as the **Sonoran Desert Unit** in "Mojave and Sonoran Desert Scrub" conservation target

LETH (San Joaquin population) is in the **Colorado Desert Unit in the "** Desert Wash Woodland and Scrub" and "Scrub and Sparsely vegetated Desert Dune" conservation targets.

"Key pressures" on these Conservation Targets that include thrashers are identified in CDFW 2015 (Table 5.6-4) and are listed below. Many of the pressures are described in detail in CDFW (2015) Volume 1, Chapter 5.6.

For Shadscale-Saltbush Scrub: Airborne pollutants; Annual and perennial non-timber crops; Climate change; Commercial and industrial area; Housing and urban areas; Industrial and military effluents; Invasive plants/animals; Livestock, farming, and ranching; Military activities; Mining and quarrying; Recreational activities; Renewable energy; Roads and railroads; and Utility and service lines.

For Mojave and Sonoran Desert Scrub: Annual and perennial non-timber crops; Climate change; Commercial and industrial area; Housing and urban areas; Invasive plants/animals; Renewable energy; Roads and railroads and Utility and service lines.

For Desert Wash Woodland and Scrub: Climate change; Commercial and industrial area; Dams and water management/use; Housing and urban areas; Military activities; Mining and quarrying; Recreational activities; Renewable energy; Roads and railroads; Tourism and recreation activities and Utility and service lines.

For Scrub and Sparsely vegetated Desert Dune: Climate change; Commercial and industrial area; Housing and urban areas; Invasive plants/animals; Livestock, farming, and ranching; Recreational activities; Renewable energy and Tourism and recreation activities.

Housing and urban development remains a key and common factor in habitat loss and related degradation in all of these conservation targets. As stated in CDFW 2015 (pg. 5.1-26) the conservation of this species will need to occur primarily on existing public lands managed by BLM.

Nevada

Nevada's 2012-2022 State Wildlife Action Plan identifies LeConte's Thrasher and Bendire's Thrasher as Species of Conservation Priority (pg. 77, 78, s-105, and s-128) of the Plan.

Bendire's Thrasher

CONSERVATION CHALLENGES:

Vulnerable to fire and urban, suburban, agricultural, and energy development. This species has low population numbers (probably not historically very numerous) and is more vulnerable to habitat degradation.

NEEDS:

Research Needs: Develop improved methods for monitoring species; collect additional monitoring data to better determine habitat use parameters. Information is needed on habitat preferences, and response to habitat changes to better understand the potential for maintaining or restoring populations. Information is needed on incubation and nestling periods; predators and competitors; brood parasitism rates and behavioral response; diet and foraging strategies; migration; winter range and ecology; habitat preferences; landscape relationships; and metapopulation structure and dynamics.

Monitoring and Existing Plans: The NV All Bird Count program captures this species. Species is covered in the Clark County MSHCP, Partners in Flight North American Landbird Conservation Plan, and the Nevada Comprehensive Bird Conservation Plan.

Approach: Determine population status, distribution, and trend in NV. Determine connectivity of NV populations to surrounding populations. Identify factors leading to population declines. Promote additional land protections for critical habitat.

LeConte's Thrasher

CONSERVATION CHALLENGES:

Sensitive to habitat fragmentation, degradation, or conversion stemming from a variety of disturbances including development (urban, agricultural, or industrial), heavy OHV use, and fire (Sheppard 1996); extended late-summer livestock grazing (Shuford and Gardali 2008); energy development and invasive plants.

NEEDS:

Research Needs: Improve monitoring efforts and generate improved population size and trend estimates; estate population losses to solar and wind development scenarios and develop mitigation strategies to offset temporary or permanent displacement.

Monitoring and Existing Plans: NV All Bird Count program captures this species. Species is covered in the Partners in Flight North American Landbird Conservaton Plan, Clark County MSHCP, and the Nevada Comprehensive Bird Conservation Plan.

Approach: Sensitivity to habitat alteration makes this species a good indicator of habitat quality, therefore, protect occupied habitat at the recommended patch size from habitat

conversion and development; maintain corridors of suitable habitat between occupied areas; minimize habitat fragmentation where development occurs focusing on maintaining larger contiguous habitat patches.

New Mexico

Bendire's thrasher (*Toxostoma bendirei*) is listed as a Species of Greatest Conservation Need (SGCN) in the Department of Game and Fish State Wildlife Action Plan (SWAP) for New Mexico (2016). The species is listed as an "Immediate Priority" SGCN due to "Declining" and "Vulnerable" status for multiple habitats within the Colorado Plateaus, High Plains and Tablelands, Chihuahuan Desert, Madrean Archipelago, and Arizona-New Mexico Mountains ecoregions (Table 11, page 96; Table 19, page 150; Table 23, page 175; Table 27, page 203; and Table 31, page 227). Threats to this species include "Natural System Modification" and "Invasive and Problematic Species;" influencing factors include a "small and restricted" total population, and "significant rangewide population declines potentially related to habitat changes or to unknown factors" (Appendix F, page 314).
Proposed conservation actions addressing "Natural System Modification" and "Invasive and Problematic Species" threats potentially applicable to Bendire's thrasher within listed ecoregion.

- Determine beneficial fire frequencies and intensities and work with land management agencies and private landowners to develop fire management plans and implement prescribed burns that avoid disturbing SGCN during sensitive periods (e.g., nesting), maintain condition of sensitive habitats (e.g., riparian habitat) and protect people and property. Potential collaborators: BLM, NPS, USFS, SLO, SFD, private landowners (pages 114, 165, 195, 217, and 245).

- Promote land management practices, standards, and guidelines to conserve and/or restore structure and function of corridors that provide important habitat for SGCN. This should include xeric riparian communities that serve as important migratory corridors for birds and other wildlife while providing ecosystem services, and wildlife corridors that link isolated mountain ranges and coniferous forest patches. Potential collaborators: BLM, NPS, USFS, USFWS, NHNM, universities (pages 114, 165, 195, 218, and 245).

- Promote land management strategies that will inhibit the spread of cheatgrass. Potential collaborators: BLM, USFS, SLO (page 115).

- Determine historic and current SGCN habitats infested with cheatgrass. Work with landowners and land management agencies to restore these areas to native species. Potential collaborators: BLM, USFS, SLO, private landowners (pages 115 and 245).

- Determine the distribution of all invasive and problematic species found in this ecoregion, and assess related threats to SGCN. Potential collaborators: BLM, USFS, universities (page 115).

- Develop strategies to prevent emerging diseases from getting into the … ecoregion[s], as well as strategies that will inhibit the spread of ones already there. Potential collaborators: universities (pages 115, 166, 196, and 219).

- Identify or develop an accessible common database of information to document the status and condition of, threats to, and conservation actions implemented in … ecoregion habitats. Identify data gaps and varying data collection methodologies that provide a framework for identifying and promoting robust standard monitoring approaches. Potential collaborators: universities. NHNM (pages 116, 168, 198, 220, and 248).

- Reduce shrub encroachment in grassland habitats important to SGCN. This may be achieved through reduction of processes that promote shrub encroachment, implementation of a natural fire regime, reseeding with native grasses, and shrub removal. Potential collaborators: ACOE, BLM, BOR, DOD, NPS, USFWS, SLO, private landowners (pages 165, 195, and 217).

- Examine the structural characteristics of habitat fragmentation and how it influences patch size, edge effect, dispersal behavior, and daily and seasonal movements/migrations by wildlife including SGCN. Focus on riparian and aquatic habitats. Potential collaborators: BLM, USFS, USFWS, NHNM, NMED, SLO, universities (pages 115, 166, 196, 218, and 246).

- Design and implement protocols for early detection of invasive and problematic species and diseases. Quickly respond to detection. Potential collaborators: BLM, USFS, SLO, NMED, universities (pages 166, 196, and 246).

- Implement early detection protocols and treatment to prevent invasive and problematic species and emerging diseases from becoming established. Potential collaborators: BLM, USFWS, USFS, EMNRD, NMDA, resource management districts (page 196).

- Eradicate or control existing non-native and invasive species before they become established. Potential collaborators: BLM, USFS, SLO, universities (pages 166, 196, and 246).

- Eradicate non-native species and restore native species. Potential collaborators: BLM, USFS, SLO, NMDA, universities (page 219).

- Reduce or eradicate non-native species and diseases as necessary to achieve restoration of native species and communities. Potential collaborators: BLM, DOD, USFWS, USFS, EMNRD, NMDA, resource management districts (page 196).

- Determine the current distribution of invasive and problematic species and diseases and their impacts on SGCN. Potential collaborators: BLM, BOR, ACOE, SLO, NMED, universities (pages 166 and 219).

- Determine the current distribution and impact on SGCN and disturbance regimes of invasive and problematic species and diseases. Potential collaborators: BLM, NRCS, USFS, SLO, private landowners (page 246).

Potentially applicable "general conservation actions" for the ecoregions where Bendire's thrashers are listed in New Mexico include the following: cheatgrass management in the Colorado Plateaus, and balancing cost-effective livestock production with adequate habitat for the High Plains and Tablelands, Chihuahuan Desert, and Madrean Archipelago (page vi). Additional proposed conservation actions potentially applicable to Bendire's thrasher within listed ecoregions include:

- Determine where habitat restoration would benefit SGCN and work with federal, state, and private land managers to restore degraded rangelands to good or excellent condition. Monitor restoration results to develop and initiate any identified improvements to restoration practices. Potential collaborators: BLM, USFS, SLO, private land managers (page 111, 162, 192, 215, and 242).

- Establish baseline composition, condition, and function of major range habitats to inform habitat restoration actions. Potential collaborators: BLM, USFS, universities (pages 111, 162, 191, 215, and 242).

- Determine how timing, intensity, and duration of livestock grazing affect SGCN and their habitats, including the interaction between grazing, fire, and the spread of invasive and problematic species. Potential collaborators: BLM, NRCS, USFS, NMDA, SLO, universities, private land managers (pages 111, 162, 192, 215, and 242).

- Promote expanded use of appropriate, cost effective, grazing practices that ensure longterm ecological sustainability for SGCN and their habitats (especially riparian habitats). These include actions that contribute to recovery of rangelands impacted by drought and allow restoration activities to be completed (Gripne 2005). Potential collaborators: BLM, USFS, SLO, private land managers (pages 111, 192, 215, and 242).

- Promote grazing systems that address both livestock and SGCN habitat needs based on site-specific conditions. When particular habitat components need improvement, coordinate with ranchers and resource managers to identify and

implement modifications that would provide the desired habitat outcomes. Potential collaborators: BLM, USFS, SLO, private landowners (pages 111, 162, 192, 215, and 242).

- Gather and assess current information on grazing practices and determine how the Department can support landowners that provide habitat for wildlife. Potential collaborators: BLM, USFS, NRCS, NMDA, SLO, private organizations (pages 111, 162, 192, 215, and 242).

- Promote rest-rotation and/or deferred-rotation grazing systems that incorporate rested pastures and help improve overall range condition and enhanced wildlife habitat. When drought or other conditions that limits grazing occur, these rested pastures can provide forage reserves and relieve pressure on grazed pastures or allotments and provide time for owners to make contingency plans for excess livestock. Potential collaborators: BLM, USFWS, USFS, NRCS, SLO, private landowner (pages 111, 162-163, 191, 215, and 243).

- Minimize the impact of energy development and mining, especially habitat fragmentation, on SGCN. This includes mitigating the impact of renewable energy development projects, such as solar power plants and geothermal development, on wildlife. Potential collaborators: BLM, EMNRD, NMED, SLO, private industry (page 216).

- Prevent direct take of wildlife associated with energy development and mining. Potential collaborators: BLM, EMNRD, NMED, SLO, private industry (page 216).

- Site and consolidate utility corridors to minimize adverse effects to SGCN. Potential collaborators: BLM, USFS, SLO, utility companies (pages 163, 193, 216, and 243).

- Determine how regional and global climate change will affect SGCN, vegetation patterns, and community and ecosystem processes and dynamics. Of importance are impacts on travel corridors, SGCN, habitat connectivity, and SGCN distribution. Plan and complete projects that help maintain the distribution and natural functioning of climate-impacted species and habitats. Potential collaborators: USFS, USFWS, USGS, universities (pages 116, 167, 197, 219, and 247).

- Determine ecology, distribution, status and trends of, and threats to SGCN (especially invertebrates that are not currently monitored and riparian-obligate species) and their habitats. Use this information to develop and implement effective monitoring protocols and conservation actions. Potential collaborators: BLM, USFS, universities, non-profit organizations, private industry (pages 116, 197, and 219).

- Assess the synergistic effects between climate change and other threats to SGCN and their habitats. Potential collaborators: USFS, USGS, universities (pages 116, 168, 197, 219, and 247).

- Develop new species recovery plans that consider the current status of and limiting factors for species, as well as projected future conditions for both species and their habitats (pages 116, 168, 198, 220, and 247).

- Inform the public about potential adverse effects of climate change on SGCN and their habitats. Potential collaborators: USFS, USGS, universities, non-profit organizations. Monitor SGCN to determine long-term trends that correlate to ecosystem dynamics and habitat changes. Potential collaborators: BLM, USFS, universities, TNC (pages 167 and 220).

Utah

Bendire's Thrasher appears on Utah's SGCN list based on two primary Crucial Data Gaps: Inadequate Understanding of Distribution or Range (p. 258-263) and Inadequate Inventory and Assessment Methods (p. 264-272). The State's involvement in the DTWG 2018 survey program was a first step in addressing these shortcomings.

LeConte's Thrasher is not currently on Utah's SGCN list or addressed in the WAP. The known ranges of each species in Utah are included in the Key Habitats identified in Utah's WAP.

The Mojave Desert Shrub Key Habitat (p. 111-114) encompasses all known Le Conte's Thrasher records from Utah and a majority of Bendire's Thrasher records. Threats to this habitat are identified as: inappropriate (increased frequency) fire regime, invasive plants (which exacerbate increased fire frequency), improper grazing, and urban/housing encroachment. Proposed corrective measures for current conditions include reducing the incidence of fire, controlling invasive plant species, and establishing methods for effective vegetative enhancement. Vegetative restoration is complicated by extreme aridity and infertile soil conditions. Bendire's Thrasher has also been reported from Lowland Sagebrush Key Habitat (p. 106-110). This is one of the most widely distributed habitat categories in the state. Identified threats include altered fire regime, drought, invasive plants, habitat shifting, improper grazing, brush removal and vegetative treatments, and urban/housing encroachment. Restoration activities in this Key Habitat are widespread. Efforts include re-establishing plant diversity and age classes, returning to a natural fire regime, developing appropriate native plant cultivars, promoting appropriate grazing practices and encouraging proper municipal planning.

The Desert Grassland Key Habitat (p. 95-98), though with restricted distribution, can also provide suitable conditions for Bendire's Thrasher. This habitat faces threats from inappropriate fire regime, invasive plants, improper grazing, OHV use, and urban/housing

encroachment. Proposed restoration methods mirror those of the two preceding habitat classifications.

Appendix 2. Non-Target and Target Species Found on Desert Thrasher Surveys 2017-2018

All species, all states:

Species	Count	Species	Count	Species	Count	Species	Count
Abert's Towhee	6	Cassin's Sparrow	4	Lark Bunting	569	Sagebrush Sparrow	9
American Goldfinch	1	Cassin's Vireo	1	Lark Sparrow	99	Sandhill Crane	208
American Kestrel	40	Chestnut-collared Longspur	2	Lazuli Bunting	16	Savannah Sparrow	16
American Pipit	236	Chihuahuan Raven	112	LeConte's Thrasher	267	Say's Phoebe	149
American Robin	12	Chipping Sparrow	400	Lesser Goldfinch	76	Scaled Quail	16
American White Pelican	35	Chukar	1	Lesser Nighthawk	47	Scott's Oriole	150
American Wigeon	4	Clay-colored Sparrow	80	Lincoln's Sparrow	12	Sharp-shinned Hawk	1
Anna's Hummingbird	4	Cliff Swallow	34	Loggerhead Shrike	291	Short-eared Owl	3
Ash-throated Flycatcher	1110	Common Nighthawk	12	Long-billed Curlew	1	Solitary Vireo	1
Audubon's Warbler	27	Common Poorwill	18	Long-billed Dowitcher	3	Song Sparrow	3
Bank Swallow	2	Common Raven	613	Lucy's Warbler	94	Spotted Towhee	26
Barn Swallow	116	Common Yellowthroat	2	MacGillivray's Warbler	11	Swainson's Hawk	24
Bell's Sparrow	153	Cooper's Hawk	16	Merlin	1	Swainson's Thrush	2
Bell's Vireo	5	Costa's Hummingbird	140	Mountain Bluebird	18	Townsend's Warbler	17
Bendire's Thrasher	85	Crissal Thrasher	133	Mountain Chickadee	2	Tree Swallow	186
Bewick's Wren	196	Curve-billed Thrasher	115	Mountain White-crowned Sparrow	3	Turkey Vulture	126
Black Phoebe	2	Dark-eyed Junco	10	Mourning Dove	751	Vaux's Swift	3
Black-billed Magpie	1	Dusky Flycatcher	12	Myrtle Warbler	1	Verdin	818
Black-chinned Hummingbird	19	Dusky-capped Flycatcher	2	Nashville Warbler	1	Vermilion Flycatcher	3

Species	Count	Species	Count	Species	Count	Species	Count
Black-crowned Night-Heron	1	Eastern Meadowlark	30	Northern Cardinal	20	Vesper Sparrow	84
Black-headed Grosbeak	17	Eurasian Collared-Dove	26	Northern Flicker	87	Violet-green Swallow	123
Black-tailed Gnatcatcher	873	European Starling	10	Northern Harrier	48	Virginia Rail	1
Black-throated Gray Warbler	27	Gambel's Quail	477	Northern Mockingbird	593	Virginia's Warbler	1
Black-throated Sparrow	7394	Gambel's White-crowned Sparrow	107	Northern Rough-winged Swallow	35	Warbling Vireo	13
Blue Grosbeak	8	Gila Woodpecker	106	Olive-sided Flycatcher	1	Western Bluebird	3
Blue-gray Gnatcatcher	140	Gilded Flicker	45	Orange-crowned Warbler	13	Western Flycatcher	19
Botteri's Sparrow	2	Golden Eagle	14	Oregon Junco	1	Western Kingbird	113
Brewer's Blackbird	141	Gray Flycatcher	78	Pacific-slope Flycatcher	6	Western Meadowlark	126
Brewer's Sparrow	2996	Gray Vireo	19	Peregrine Falcon	2	Western Tanager	42
Broad-tailed Hummingbird	24	Great Horned Owl	7	Phainopepla	609	Western Wood-Pewee	23
Bronzed Cowbird	4	Greater Roadrunner	40	Pine Siskin	2	White-breasted Nuthatch	2
Brown-crested Flycatcher	9	Greater Yellowlegs	1	Pinyon Jay	74	White-crowned Sparrow	1529
Brown-headed Cowbird	171	Great-tailed Grackle	5	Plumbeous Vireo	3	White-tailed Kite	2
Bullock's Oriole	31	Green-tailed Towhee	20	Prairie Falcon	8	White-throated Swift	10
Burrowing Owl	11	Hammond's Flycatcher	3	Purple Martin	13	White-winged Dove	110
Bushtit	20	Hairy Woodpecker	1	Pyrrhuloxia	39	Willet	6

Species	Count	Species	Count	Species	Count	Species	Count
Cactus Wren	921	Harris's Hawk	2	Red-shafted Flicker	7	Willow Flycatcher	1
California Gull	82	Hermit Thrush	2	Red-tailed Hawk	123	Wilson's Phalarope	1
California Quail	19	Hooded Oriole	10	Red-winged Blackbird	249	Wilson's Snipe	1
Calliope Hummingbird	5	Horned Lark	1545	Rock Wren	332	Wilson's Warbler	145
Canada Goose	2	House Finch	1049	Ruby-crowned Kinglet	19	Woodhouse's Scrub-Jay	30
Canyon Towhee	65	House Wren	10	Rufous Hummingbird	2	Yellow Warbler	25
Canyon Wren	11	Juniper Titmouse	30	Rufous-winged Sparrow	1	Yellow-headed Blackbird	1
Cassin's Finch	20	Killdeer	1	Sage Sparrow	228	Yellow-rumped Warbler	77
Cassin's Kingbird	17	Ladder-backed Woodpecker	201	Sage Thrasher	187		

Total 29825

Species found in Arizona:

Species	Count	Species	Count	Species	Count
Abert's Towhee	4	Costa's Hummingbird	28	Northern Rough-winged Swallow	2
American Goldfinch	1	Crimson-bellied Woodpecker	1	Phainopepla	172
American Kestrel	4	Crissal Thrasher	25	Pinyon Jay	15
American Pipit	220	Curve-billed Thrasher	107	Plumbeous Vireo	2
American Robin	7	Dark-eyed Junco	2	Purple Martin	4
Anna's Hummingbird	3	Eurasian Collared-Dove	8	Pyrrhuloxia	19
Ash-throated Flycatcher	267	European Starling	10	Red-tailed Hawk	25
Audubon's Warbler	2	Gambel's Quail	210	Red-winged Blackbird	244
Barn Swallow	2	Gambel's White-crowned Sparrow	23	Rock Wren	5
Bell's Vireo	4	Gila Woodpecker	106	Ruby-crowned Kinglet	3

Species	Count	Species	Count	Species	Count
Bendire's Thrasher	47	Gilded Flicker	27	Rufous Hummingbird	1
Bewick's Wren	25	Gray Flycatcher	2	Rufous-winged Sparrow	1
Black-chinned Hummingbird	4	Great Horned Owl	5	Sage Thrasher	15
Black-headed Grosbeak	7	Greater Roadrunner	21	Savannah Sparrow	1
Black-tailed Gnatcatcher	247	Green-tailed Towhee	2	Say's Phoebe	14
Black-throated Gray Warbler	1	Harris's Hawk	2	Scaled Quail	2
Black-throated Sparrow	1083	Hooded Oriole	3	Scott's Oriole	52
Blue-gray Gnatcatcher	3	Horned Lark	59	Tree Swallow	23
Brewer's Blackbird	140	House Finch	148	Turkey Vulture	75
Brewer's Sparrow	432	House Wren	3	Verdin	168
Brown-crested Flycatcher	6	Juniper Titmouse	8	Vesper Sparrow	9
Brown-headed Cowbird	127	Ladder-backed Woodpecker	32	Violet-green Swallow	24
Bullock's Oriole	2	Lark Bunting	1	Western Kingbird	41
Bushtit	1	Lark Sparrow	41	Western Meadowlark	1
Cactus Wren	326	Lazuli Bunting	1	Western Tanager	8
California Quail	1	Lesser Goldfinch	17	Western Wood-Pewee	1
Canyon Towhee	47	Lesser Nighthawk	4	White-breasted Nuthatch	1
Canyon Wren	3	Lincoln's Sparrow	6	White-crowned Sparrow	364
Chihuahuan Raven	1	Loggerhead Shrike	16	White-winged Dove	103
Chipping Sparrow	143	Lucy's Warbler	77	Wilson's Warbler	8
Cliff Swallow	2	Mourning Dove	238	Woodhouse's Scrub-Jay	2
Common Nighthawk	5	Northern Cardinal	20	Yellow Warbler	1
Common Poorwill	3	Northern Flicker	7	Yellow-rumped Warbler	9
Common Raven	161	Northern Harrier	2		
Cooper's Hawk	8	Northern Mockingbird	87		

Total 6111

Species found in California:

Species	Count	Species	Count	Species	Count
American Kestrel	5	Eurasian Collared-Dove	6	Phainopepla	266
American Pipit	1	Gambel's Quail	41	Pine Siskin	2
American Robin	1	Gilded Flicker	5	Red-tailed Hawk	5
Ash-throated Flycatcher	190	Gray Flycatcher	7	Rock Wren	24
Audubon's Warbler	13	Great Horned Owl	1	Ruby-crowned Kinglet	9
Bank Swallow	1	Green-tailed Towhee	1	Sage Thrasher	37
Barn Swallow	17	Hammond's Flycatcher	3	Savannah Sparrow	4
Bell's Sparrow	119	Hermit Thrush	1	Say's Phoebe	15
Bendire's Thrasher	24	Horned Lark	118	Scott's Oriole	36
Bewick's Wren	72	House Finch	210	Swainson's Thrush	2
Black-chinned Hummingbird	4	House Wren	3	Townsend's Warbler	12
Black-headed Grosbeak	4	Ladder-backed Woodpecker	62	Tree Swallow	86
Black-tailed Gnatcatcher	243	Lark Bunting	1	Turkey Vulture	6
Black-throated Gray Warbler	1	Lark Sparrow	9	Unid. Empidonax Flycatcher	5
Black-throated Sparrow	907	Lazuli Bunting	10	Unid. Hummingbird	2
Blue-gray Gnatcatcher	57	LeConte's Thrasher	35	Vaux's Swift	2
Brewer's Blackbird	1	Lesser Goldfinch	4	Verdin	241
Brewer's Sparrow	271	Lesser Nighthawk	2	Violet-green Swallow	9
Brown-headed Cowbird	3	Lincoln's Sparrow	1	Warbling Vireo	9
Bullock's Oriole	11	Loggerhead Shrike	69	Western Flycatcher	18
Cactus Wren	126	Lucy's Warbler	8	Western Kingbird	12
California Quail	18	MacGillivray's Warbler	4	Western Meadowlark	6
Calliope Hummingbird	5	Mountain Bluebird	6	Western Tanager	29
Cassin's Kingbird	1	Mourning Dove	34	Western Wood-Pewee	10
Chipping Sparrow	10	Nashville Warbler	1	White-crowned Sparrow	580
Cliff Swallow	3	Northern Flicker	1	White-throated Swift	2
Common Poorwill	5	Northern Mockingbird	70	White-winged Dove	5
Common Raven	62	Northern Rough-winged Swallow	1	Wilson's Warbler	54
Cooper's Hawk	2	Olive-sided Flycatcher	1	Yellow Warbler	17

Species	Count	Species	Count	Species	Count
Costa's Hummingbird	47	Orange-crowned Warbler	13	Yellow-rumped Warbler	23
Crissal Thrasher	24	Oregon Junco	1		
Dusky Flycatcher	2	Pacific-slope Flycatcher	6		
		Total 4910			

Species found in Nevada:

Species	Count	Species	Count	Species	Count
American Kestrel	22	Gambel's Quail	195	Ruby-crowned Kinglet	6
American Pipit	7	Gambel's White-crowned Sparrow	84	Rufous Hummingbird	1
American Robin	4	Gilded Flicker	13	Sage Sparrow	179
American Wigeon	4	Golden Eagle	11	Sage Thrasher	119
Anna's Hummingbird	1	Gray Flycatcher	60	Sagebrush Sparrow	4
Ash-throated Flycatcher	559	Gray Vireo	12	Samuel's Song Sparrow	5
Audubon's Warbler	12	Great Horned Owl	1	Savannah Sparrow	7
Bank Swallow	1	Greater Roadrunner	8	Say's Phoebe	58
Barn Swallow	64	Greater Yellowlegs	1	Scott's Oriole	49
Bell's Sparrow	34	Great-tailed Grackle	2	Sharp-shinned Hawk	1
Bendire's Thrasher	13	Green-tailed Towhee	12	Short-eared Owl	1
Bewick's Wren	88	Hoffmann's Woodpecker	1	Solitary Vireo	1
Black Phoebe	2	Hooded Oriole	2	Spotted Towhee	25
Black-billed Magpie	1	Horned Lark	938	Swainson's Hawk	4
Black-chinned Hummingbird	4	House Finch	467	Townsend's Warbler	3
Black-crowned Night-Heron	1	House Wren	2	Tree Swallow	69
Black-headed Grosbeak	6	Juniper Titmouse	13	Turkey Vulture	27
Black-tailed Gnatcatcher	349	Killdeer	1	Unid. Empidonax Flycatcher	10
Black-throated Gray Warbler	25	Ladder-backed Woodpecker	100	Vaux's Swift	1
Black-throated Sparrow	4623	Lark Sparrow	21	Verdin	367
Blue-gray Gnatcatcher	75	Lazuli Bunting	5	Vesper Sparrow	12

Species	Count	Species	Count	Species	Count
Brewer's Sparrow	1106	LeConte's Thrasher	232	Violet-green Swallow	81
Broad-tailed Hummingbird	4	Lesser Goldfinch	48	Virginia Rail	1
Brown-headed Cowbird	29	Lesser Nighthawk	30	Virginia's Warbler	1
Bullock's Oriole	14	Lincoln's Sparrow	3	Warbling Vireo	4
Burrowing Owl	4	Loggerhead Shrike	186	Western Bluebird	2
Bushtit	18	Lucy's Warbler	5	Western Flycatcher	1
Cactus Wren	319	MacGillivray's Warbler	5	Western Kingbird	21
California Gull	82	Merlin	1	Western Meadowlark	25
Canada Goose	2	Mountain Bluebird	9	Western Tanager	4
Canyon Wren	8	Mountain White-crowned Sparrow	1	Western Wood-Pewee	11
Cassin's Finch	2	Mourning Dove	373	White-crowned Sparrow	506
Cassin's Kingbird	1	Myrtle Warbler	1	White-throated Swift	8
Cassin's Vireo	1	Northern Flicker	68	White-winged Dove	1
Chipping Sparrow	161	Northern Harrier	13	Willow Flycatcher	1
Chukar	1	Northern Mockingbird	319	Wilson's Phalarope	1
Cliff Swallow	26	Northern Rough-winged Swallow	29	Wilson's Snipe	1
Common Nighthawk	5	Peregrine Falcon	2	Wilson's Warbler	69
Common Poorwill	10	Phainopepla	166	Woodhouse's Scrub-Jay	17
Common Raven	218	Pinyon Jay	50	Worm-eating Warbler	2
Common Yellowthroat	2	Plumbeous Vireo	1	Yellow Warbler	7
Cooper's Hawk	4	Prairie Falcon	5	Yellow-rumped Warbler	11
Costa's Hummingbird	65	Red-shafted Flicker	7	Yellow Warbler	7
Crissal Thrasher	61	Red-tailed Hawk	79		
Dusky Flycatcher	4	Red-winged Blackbird	5		
Eurasian Collared-Dove	7	Rock Wren	257		

Total 13607

Species found in New Mexico:

Species	Count	Species	Count	Species	Count
Abert's Towhee	2	Curve-billed Thrasher	8	Purple Martin	9
American Kestrel	8	Dark-eyed Junco	4	Pyrrhuloxia	20
Ash-throated Flycatcher	65	Dusky Flycatcher	6	Red-tailed Hawk	12
Barn Swallow	33	Dusky-capped Flycatcher	2	Rock Wren	29
Bell's Vireo	1	Eastern Meadowlark	30	Ruby-crowned Kinglet	1
Bendire's Thrasher	1	Eurasian Collared-Dove	5	Sage Sparrow	28
Bewick's Wren	11	Gambel's Quail	29	Sage Thrasher	12
Black-chinned Hummingbird	6	Golden Eagle	3	Sandhill Crane	208
Black-tailed Gnatcatcher	33	Gray Flycatcher	9	Savannah Sparrow	4
Black-throated Sparrow	582	Gray Vireo	7	Say's Phoebe	31
Blue Grosbeak	8	Greater Roadrunner	11	Scaled Quail	14
Blue-gray Gnatcatcher	2	Great-tailed Grackle	3	Scott's Oriole	13
Botteri's Sparrow	2	Green-tailed Towhee	5	Short-eared Owl	2
Brewer's Sparrow	1116	Hermit Thrush	1	Spotted Towhee	1
Broad-tailed Hummingbird	17	Hooded Oriole	5	Swainson's Hawk	20
Bronzed Cowbird	4	Horned Lark	321	Townsend's Warbler	2
Brown-crested Flycatcher	3	House Finch	88	Tree Swallow	8
Brown-headed Cowbird	12	House Wren	2	Turkey Vulture	13
Bullock's Oriole	4	Juniper Titmouse	9	Unid. Sparrow	7
Burrowing Owl	6	Ladder-backed Woodpecker	7	Verdin	40
Bushtit	1	Lark Bunting	567	Vermilion Flycatcher	3
Cactus Wren	101	Lark Sparrow	25	Vesper Sparrow	46
Canyon Towhee	18	Lesser Nighthawk	11	Violet-green Swallow	9
Cassin's Finch	18	Lincoln's Sparrow	2	Western Bluebird	1
Cassin's Kingbird	15	Loggerhead Shrike	19	Western Kingbird	30

Species	Count	Species	Count	Species	Count
Cassin's Sparrow	4	Lucy's Warbler	2	Western Meadowlark	47
Chestnut-collared Longspur	2	MacGillivray's Warbler	2	Western Tanager	1
Chihuahuan Raven	111	Mountain Chickadee	2	Western Wood-Pewee	1
Chipping Sparrow	76	Mourning Dove	98	White-breasted Nuthatch	1
Clay-colored Sparrow	80	Northern Flicker	11	White-crowned Sparrow	38
Cliff Swallow	3	Northern Harrier	32	White-tailed Kite	2
Common Nighthawk	2	Northern Mockingbird	112	White-winged Dove	1
Common Raven	86	Northern Rough-winged Swallow	3	Wilson's Warbler	13
Cooper's Hawk	2	Pinyon Jay	9	Woodhouse's Scrub-Jay	9
Crissal Thrasher	23	Prairie Falcon	2	Yellow-rumped Warbler	33

Total 4619

Species found in Utah:

Species	Count	Species	Count	Species	Count
American Kestrel	1	Horned Lark	109	Rock Wren	17
American Pipit	8	House Finch	136	Sage Sparrow	21
American White Pelican	35	Lark Sparrow	3	Sage Thrasher	4
Ash-throated Flycatcher	29	Lesser Goldfinch	7	Say's Phoebe	31
Black-chinned Hummingbird	1	Loggerhead Shrike	1	Song Sparrow	3
Black-tailed Gnatcatcher	1	Long-billed Curlew	1	Turkey Vulture	5
Black-throated Sparrow	199	Long-billed Dowitcher	3	Verdin	2
Blue-gray Gnatcatcher	3	Lucy's Warbler	2	Vesper Sparrow	17
Brewer's Sparrow	71	Mountain Bluebird	3	Western Kingbird	8
Broad-tailed Hummingbird	3	Mountain White-crowned Sparrow	2	Western Meadowlark	47
Burrowing Owl	1	Mourning Dove	8	White-crowned Sparrow	41
Cactus Wren	49	Northern Harrier	1	Willet	6
Chipping Sparrow	10	Northern Mockingbird	5	Woodhouse's Scrub-Jay	2
Common Raven	86	Phainopepla	5	Yellow-headed Blackbird	1
Dark-eyed Junco	4	Prairie Falcon	1	Yellow-rumped Warbler	1
Gambel's Quail	2	Red-tailed Hawk	2		

Total 998