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Landbird Monitoring in the Chihuahuan Desert Network

2010–2017 Synthesis Report

Natural Resource Report NPS/CHDN/NRR—2024/2643









ON THE COVER

Clockwise from top left: Black-throated Sparrow, Verdin, Pyrrhuloxia, and Ash-throated Flycatcher. Photos © Robert Shantz.

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2010–2017 Synthesis Report

Natural Resource Report NPS/CHDN/NRR—2024/2643

Jessica Colbaugh [1]
Robert A. Gitzen [1]
Patricia Valentine-Darby [2]
Greg Levandoski [3]
Melissa A. Powell [4]

[1] School of Forestry and Wildlife Sciences
Auburn University
602 Duncan Drive
Auburn, AL 36849

[2] Northern Rockies Conservation Cooperative, in partnership with
National Park Service
Chihuhuan Desert Inventory & Monitoring Network
3655 Research Drive, Genesis D
Las Cruces, New Mexico 88003

[3] Regalis Environmental LLC
Longmont, Colorado 80501

[4] Tucson Audubon Society, in partnership with
National Park Service
Chihuhuan Desert Inventory & Monitoring Network
3655 Research Drive, Genesis D
Las Cruces, New Mexico 88003

Editing and Layout
Patricia Valentine-Darby

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Executive Summary

The mission of the National Park Service (NPS) is to manage park resources "unimpaired for future generations." Protecting and managing some of our nation's most significant natural resources requires basic knowledge of the condition of ecosystems and species that occur in national parks. In order to better meet this mission, the Inventory & Monitoring (I&M) Program was established to determine status and trends in ecological resources. Established in 2001, the Chihuahuan Desert Inventory and Monitoring Network (CHDN) includes seven parks in southern New Mexico and western Texas: Amistad National Recreation Area (NRA), Big Bend National Park (NP), Carlsbad Caverns NP, Fort Davis National Historic Site (NHS), Guadalupe Mountains NP, Rio Grande Wild and Scenic River (WSR), and White Sands NP. The parks vary in size from 192 hectares (ha; 474 acres; Fort Davis NHS) to 324,641 ha (801,863 acres; Big Bend NP) and represent the most significant natural, cultural, and recreational values in the U.S. Chihuahuan Desert.

The CHDN began monitoring landbirds in 2010 and now has monitoring data in all parks for the breeding seasons of 2010–2016 (except 2015), as well as 2017 for Big Bend NP. The overall goal of the CHDN landbird monitoring program is to detect biologically significant changes in population and community parameters over time. Consistent with specific CHDN monitoring objectives, we focused on a set of attributes—species richness and composition, occupancy, and density—that are complementary and together provide a comprehensive assessment of changes in bird populations and communities. These monitoring objectives focus on long-term changes and trends. Prior to this current report, primarily annual, basic data summaries had been produced for each year of surveys. This report is the first synthesis report of the CHDN data.

Our intention for monitoring landbirds extends beyond the birds themselves, and includes a broader vision of landbirds as indicators of the ecosystems they inhabit. This dual purpose influenced our sampling design, especially in light of funding and logistical limitations. We sampled primarily in two habitat classes in the CHDN: grassland (upland) and riparian. Depending on park size, we used two approaches to allocate survey point locations (Generalized Random-Tessellation Stratified sampling [GRTS] in all but one park, and a systematic grid in Fort Davis NHS). Sampling locations were selected randomly within habitat classes using a design that creates a spatially-balanced distribution of points. Survey points in CHDN parks were located along a transect for linear features (e.g., most riparian habitats) or a grid for areal features. Maps of the transects and grids sampled within each CHDN park are shown in Appendix A.

Samples were replicated either spatially (for most park-habitats) or temporally. Replicating either by space or time throughout the core breeding season ensures a greater chance of detecting all breeding birds. We sampled an average of 56.6 grassland (upland) grids and 20 riparian transects in the CHDN each year. The greatest number of grassland (upland) grids was sampled in Big Bend NP, followed by White Sands NP, Guadalupe Mountains NP, and Amistad NRA. The greatest number of riparian transects was sampled in Amistad NRA and Big Bend NP.

The general window of breeding and sampling was from April through June, with adjustments for individual park visits based on park latitude and elevation. We used point-count surveys to estimate and monitor landbird population parameters. We surveyed transects/grids once each year, with the exception of the grassland (upland) grid at Fort Davis NHS and the riparian transects at Carlsbad Caverns NP and Guadalupe Mountains NP, which were visited twice each year.

From our species richness and composition analysis, we found that across all parks the largest species richness estimate was in Amistad NRA riparian habitat in 2013, and the lowest species richness estimate was in Carlsbad Caverns NP riparian habitat in 2010. In the report we also provide species richness estimates (and raw/observed richness) by park-habitat (e.g., Amistad NRA Riparian, Amistad NRA Upland) by year. Additionally, we determined the proportion of species in each breeding habitat guild (grassland/savanna, riparian/wetland, shrubland, upland generalist, or woodland) for surveyed riparian and upland habitats in each park. For each surveyed park upland, the shrubland breeding habitat guild comprised the largest proportion of species. For riparian habitat, the breeding habitat guild that comprised the largest proportion of species was more variable, with woodland, riparian/wetland, and shrubland guilds being the most species rich. In addition, with only one exception, estimated riparian species richness in Amistad NRA and Big Bend NP was higher each year than in surveyed upland habitat, reinforcing the contribution of riparian areas to overall park- and network-level biodiversity.

In total, we detected 104 breeding species that are well-surveyed by the methods used. Across parks and habitats, we obtained occupancy estimates for about 250 species-park-habitat combinations. In upland habitat we estimated occupancy for 50 species, and in riparian habitat we estimated occupancy for 58 species. Of these species, we obtained high precision (CV ≤10%) for a small subset (16 species in upland habitat and five species in riparian habitat). Similarly, across parks and habitats, we obtained density estimates for 81 species-park-habitat combinations. We estimated density of 30 species in upland habitat and 11 species in riparian habitat.

We present occupancy and density estimates from our analyses in the form of "species accounts" for all breeding species that we considered adequately surveyed by the methods used (i.e., excluding colonial, nocturnal, and low-breeding-density birds) and for which sufficient data were available for the analyses. This resulted in 51 species accounts. In addition to occupancy and density results (by park-habitat), we included a conservation status table with 12 different scores/rankings (at global, continental, federal, regional, and state scales) for each species.

Previous analyses of CHDN landbird monitoring data recommended that future occupancy analyses focus on species detected frequently enough to support reliable estimates. Eleven such species were highlighted. We excluded two of these species from our analyses because they are poorly surveyed by point counts, but we were able to estimate occupancy for the remaining nine species for at least four parks each, and each species had at least one park-habitat combination with a CV ≤10% (i.e., with high precision).

Overall, nine species that breed in grasslands and are well-surveyed by point counts were detected during surveys. We were able to estimate occupancy in at least one park-habitat for two-thirds of grassland breeding species (Blue Grosbeak, Cassin's Sparrow, Eastern Meadowlark, Horned Lark, Lark Sparrow and Loggerhead Shrike) and density in at least one park-habitat for about half of grassland breeding species (Blue Grosbeak, Cassin's Sparrow, Horned Lark, and Loggerhead Shrike). Collectively, these results indicate the potential for monitoring some species in this declining group.

The last section of our results and discussion chapter provides an overview of the occupancy and density results by park, by breeding habitat guild, and for species of conservation concern. We estimated occupancy and/or density for seven species of conservation concern: Bell's Vireo (state-threatened in New Mexico), Black-chinned Sparrow (continental watch list species), Cactus Wren (regional concern), Cassin's Sparrow (regional concern), Loggerhead Shrike (regional concern), Lucy's Warbler (regional concern), and Scott's Oriole (regional concern).

In an effort to increase the CHDN's ability to achieve landbird monitoring objectives efficiently, we assessed the seasonal timing of surveys and recommended changes. Using results for

occupancy and species richness, we also assessed the ability of the current and potential modified designs to detect trends in CHDN breeding bird populations and communities (by way of a power analysis). In CHDN monitoring to date, survey visits have occurred across a fairly wide window within the breeding season (March 28th to June 30th). Bird communities in network parks are highly dynamic within this survey window, as wintering birds and pass-through migrants may be captured in the early portion of the survey window, while late breeders may be missed or undetected. Narrowing the seasonal window within which visits can occur from year to year would increase survey precision. Doing so would reduce the chances of confounding changes in survey timing with changes in the breeding bird community.

For our power analysis, we examined how power would be affected by a less frequent survey schedule compaed to the current annual sampling schedule, as well as by a reallocation of spatial sampling effort to increase transect sample sizes per park-habitat. Based on the data and power analysis we conducted, the current landbird monitoring protocol has sufficient power to detect a 3% per year decline in species richness at the park-habitat level within about 15 years of monitoring, and to detect a 3% per year decline in occupancy within 20 to 30 years for species relatively widespread within a park-habitat (e.g., on average occurring at ≥75% of transects). However, these are likely species for which power to detect trends in density may also be adequate within the same time frame. An intended benefit of monitoring occupancy and density was the potential for occupancy to provide defensible information on changes in occurrence of less common species for which density analyses may be data limited. Unfortunately, with the current design's relatively low number of transects within most park-habitats, detecting changes in occupancy of moderately uncommon species (~25% transect occupancy) may take 30 to 40 years. Detecting changes of relatively rare species (10% transect occupancy) may take more than 40 to 50 years at most park-habitats. To put this into context, a 3% annual decline in occupancy over 40 years would result in a cumulative population decline of 70%. An annual decline of 3% over 50 years would translate to a population decline of 78%. Reallocating spatial effort—increasing the number of transects by 50 to 100% while reducing the number of points per transect—would have moderate benefits for detecting changes in occupancy while allowing more analytical flexibility (e.g., for assessing factors correlated with transect-level changes).

To date, the CHDN protocol has involved visits to each park-habitat every year. Reducing annual costs by visiting parks less frequently would lengthen the time frame for detecting moderate trends, particularly for occupancy. The potential insights gained from landbird monitoring would accrue with time, such that even less frequent visits would provide defensible information about trends in CHDN bird communities with enough decades of monitoring. However, such a time frame for detecting changes in park resources is problematic given the urgency of current threats to CHDN parks from climate change and other factors.

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Acronyms

ACAD	Avian Conservation Assessment Database
AMIS	Amistad National Recreation Area
BCR	Bird Conservation Region
BIBE	Big Bend National Park
CAVE	Carlsbad Caverns National Park
CCS	Continental Combined Score (max)
CHDN	Chihuahuan Desert Network
CI	Credible Interval
CL	Confidence Limit
CV	Coefficient of Variation
ECOS	Environmental Conservation Online
ESA	Endangered Species Act
FODA	Fort Davis National Historic Site
G Rank	Global Rank
GPS	Global Positioning System
GRTS	Generalized Random-Tessellation Stratified sampling
GUMO	Guadalupe Mountains National Park
I&M	Inventory and Monitoring
LCL	Lower confidence limit
MBTA	Migratory Bird Treaty Act
MCMC	Markov chain Monte Carlo
NABCI	North American Bird Conservation Initiative
NHS	National Historic Site
NMACP	New Mexico Avian Conservation Partners
NP	National Park
NPS	National Park Service
NRA	National Recreation Area
PIF	Partners in Flight
PT-r	Regional Population Trend
RC	Regional Concern
RD-b	Relative Density-Breeding
RIGR	Rio Grande Wild and Scenic River
RS	Regional Stewardship
SCC	Species of Conservation Concern
SE	Standard Error
SODN	Sonoran Desert Network
SOPN	Southern Plains Network
SWNC	Southwest Network Collaboration
TAS	Tucson Audubon Society
TB-r	Regional Threats-Breeding
UCL	Upper confidence limit
USFWS	U.S. Fish and Wildlife Service
WHSA	White Sands National Park
WSR	Wild and Scenic River

1 Introduction

1.1 Background

The mission of the National Park Service (NPS) is to manage park resources "unimpaired for future generations." Protecting and managing some of our nation's most significant natural resources requires basic knowledge of the condition of ecosystems and species that occur in national parks. In order to better meet this mission, the Inventory & Monitoring (I&M) Program was established to determine status and trends in ecological resources (NPS 1992). Established in 2001, the Chihuahuan Desert Inventory and Monitoring Network (CHDN) includes seven parks in southern New Mexico and western Texas: Amistad National Recreation Area (NRA), Big Bend National Park (NP), Carlsbad Caverns NP, Fort Davis National Historic Site (NHS), Guadalupe Mountains NP, Rio Grande Wild and Scenic River (WSR), and White Sands NP (Figure 1-1).

The CHDN, Sonoran Desert Network (SODN), and Southern Plains Network (SOPN) are collectively known as the Southwest Network Collaboration (SWNC). The SWNC is a joint effort between the three natural resource inventory and monitoring programs to share monitoring protocols and data collection and reporting duties. The goal of the SWNC is to improve effectiveness and efficiency across all three networks. One of the eight natural resource areas on which the networks collaborate is landbird monitoring. The three networks share a protocol (i.e., Beaupré et al. 2013), as well as uniform, overall methods and datasheets used by field crews. Data management duties are shared among the three program data management staff members. Data for all programs collaborating on a given protocol are stored in a central database accessible to all of the networks. National Park Service units within the SWNC are shown in Figure 1-2.

In addition to collaborating with one another, CHDN, SODN, and SOPN have collaborated with the Tucson Audubon Society and Bird Conservancy of the Rockies (formerly Rocky Mountain Bird Observatory) on landbird monitoring.

Monitoring changes in landbird population and community parameters can be an important element of a comprehensive, long-term monitoring program. Landbirds are a conspicuous component of many ecosystems. They have high body temperatures and rapid metabolisms, and they occupy high trophic



Figure 1-1. Park units within the Chihuahuan Desert Inventory and Monitoring Network (CHDN). Map base layer credit: NPS Park Tiles.

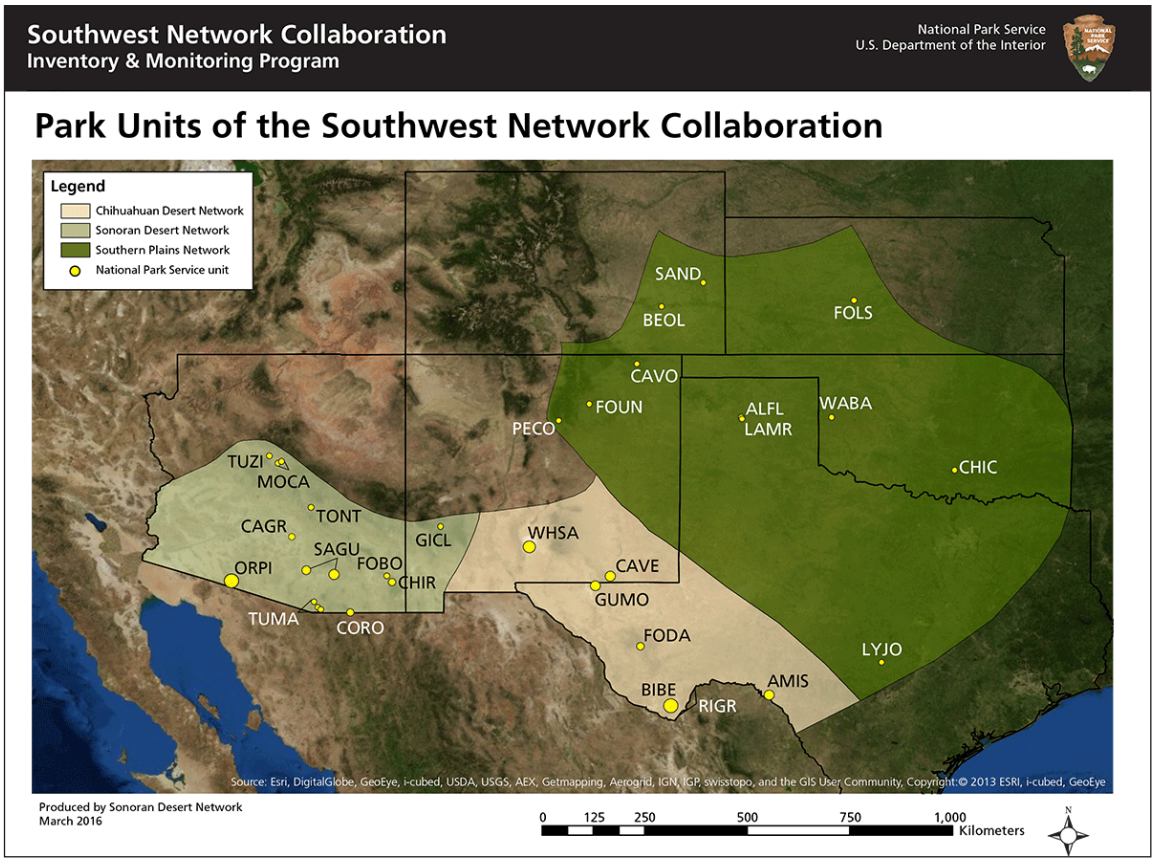


Figure 1-2. Location of park units within the Southwest Network Collaboration (SWNC). Figure Source: Sonoran Desert Network; base imagery using Esri, Maxar, Earthstar Geographics, and the GIS User Community.

levels. As such, changes in landbird populations may be indicators of changes in the biotic or abiotic components of the environment upon which they depend (Canterbury et al. 2000, Bryce et al. 2002). Relative to other vertebrates, landbirds are also highly detectable and can be efficiently surveyed with the use of numerous standardized methods (Bibby et al. 2000, Buckland et al. 2001). Dozens to hundreds of species can be monitored with the same protocol simultaneously, providing an efficiency of monitoring per species that is not possible for most other taxa.

Birds select habitat based on the presence of behavioral cues triggered by the environment (Hutto 1985, Alcock 2005). In some environments, however, especially those that vary unpredictably, habitat may not be saturated and changes in resources may not always be tracked by changes in animal populations (Wiens 1985). In these situations, relating changes in bird populations to environmental features can be complex, especially when confounded by time lags that are characteristic of site-tenacious bird species. Additional complications occur if birds respond more sensitively to environmental change than we can detect, and when random and cyclical environmental changes result in erratic changes in population size that are ultimately inconsequential. However, the utility of monitoring landbirds is strengthened by concurrent monitoring of a broad suite of environmental parameters (Dale and Beyeler 2001) that may assist in relating changes in the bird community to other environmental factors. Such a broad-based approach is now being undertaken by CHDN (NPS, CHDN 2010), SWNC partners, and other broad-based monitoring programs (e.g., Ringold et al. 1996, Stevens and Gold 2003, Barrows et al. 2005).

Perhaps the most compelling reason to monitor landbird communities is that birds themselves are inherently valuable. The high aesthetic and spiritual values that humans place on native wildlife are acknowledged in the agency's Organic Act: "to conserve . . . the

wild life therein . . . unimpaired for the enjoyment of future generations." Birdwatching, in particular, is a popular, long-standing recreational pastime in the United States, and it forms the basis of a large and sustainable industry (Sekercioglu 2002).

1.1.1 Chihuahuan Desert Network (CHDN)

The CHDN began monitoring birds in 2010. We now have monitoring data for the breeding seasons of 2010–2016 (except 2015), as well as 2017 for Big Bend NP.

Chihuahuan Desert Network parks vary in size from 192 hectares (ha; 474 acres; Fort Davis NHS) to 324,641 ha (801,863 acres; Big Bend NP) (Table 1-1). Elevation changes within a given park range from 82 meters (m; 269 feet [ft]; Amistad NRA) to 1,839 m (6,033 ft; Big Bend NP). The network park that occurs at the lowest elevation is Amistad NRA, and those that reach the highest elevations are Big Bend NP and Guadalupe Mountains NP. Also, as shown in Figures 1-1 or 1-2, White Sands NP, Carlsbad Caverns NP, and Guadalupe Mountains NP, respectively, are the northernmost parks in the network.

The seven CHDN park units represent the most significant natural, cultural, and recreational values in the U.S. Chihuahuan Desert. Most of the CHDN park units were established for conservation and preservation of significant natural and geologic resources (e.g., caverns of Carlsbad Caverns NP). The exceptions are Fort Davis NHS, which was established primarily for its historical significance, and Amistad NRA, which was established for recreation. Although not established for their natural resources, both parks contain significant natural resources embedded within a framework focused on a human event or activity.

Six of the CHDN parks (all but Amistad NRA) are located in the Chihuahuan Desert Ecoregion. Conservation organizations like World Wildlife Fund consider the Chihuahuan Desert Ecoregion as one of the most diverse deserts in the world and a critical reservoir for conserving biodiversity (Olson and Dinerstein 1998). At least 1,000 endemic plant taxa occur in the Chihuahuan Desert, an astonishing richness of biodiversity (Johnson 1974). This high desert area is a center for endemism of yuccas and cacti (Hernández and Bárcenas 1995). Three-hundred and fifty of the 1,500 known species of cacti occur in the Chihuahuan Desert. Four other plant families (grasses, euphorbs, asters, and legumes) also show high levels of endemism across the many basins of the desert (Dinerstein et al. 2000). During the last century, woody shrubs have intruded and expanded into areas of this ecosystem once dominated by or occupied by grasses (Peters and Gibbens 2006). The causes of this shift are equally diverse and complex, involving historical fauna and land use, human and animal forms of plant seed dispersal, excessive grazing, extended drought, increased atmospheric carbon dioxide, fire, redistribution and het-

Table 1-1. Size and elevation data for parks in the Chihuahuan Desert Inventory and Monitoring Network (CHDN).

Park	Park acronym	Area		Elevation Range	
		Hectares	Acres	Meters	Feet
Amistad National Recreation Area	AMIS	23,195	57,292	282–364	925–1,194
Big Bend National Park	BIBE	324,641	801,863	548–2,387	1,798–7,831
Carlsbad Caverns National Park	CAVE	18,934	46,766	1,096–1,992	3,596–6,535
Fort Davis National Historic Site	FODA	192	474	1,487–1,622	4,879–5,322
Guadalupe Mountains National Park	GUMO	34,986	86,416	1,105–2,667	3,625–8,750
Rio Grande Wild and Scenic River	RIGR	2,091	5,164	360–616	1,181–2,021
White Sands National Park	WHSA	58,191	143,733	1,185–1,290	3,888–4,232

erogeneity of soil resources, and physiological adaptations of plants (Cole and Monger 1994, Fredrickson et al. 2006, Housman et al. 2006, Peters and Gibbens 2006, Peters and Havstad 2006).

Currently, the majority (50%) of landscapes in the Northern Chihuahuan Subregion consist of desert shrublands. Desert grasslands, covering approximately 25% of the subregion, are often mosaics of grass and shrub. Mixed-conifer forests and woodlands comprise approximately 10% of the subregion. Consequently, the Chihuahuan Desert is now considered synonymous with shrublands, and its boundaries are determined by the contiguous distributions of creosote bush (*Larrea tridentata*) and tarbush (*Flourensia cernua*) (Dick-Peddie 1993). This change has increased the significance of remaining desert grasslands, particularly those once dominated by black grama (*Bouteloua eriopoda*).

Amistad NRA is located in the Tamaulipan Thornscrub (Mezquital) Ecoregion of southern Texas and northeastern Mexico. The diversity of the Tamaulipan Thornscrub is not as high as that of the Chihuahuan Desert, but it still supports over six hundred species of plants and animals. The region is particularly rich in tree species, including two endemics, and birds (Ricketts et al. 1999). In this region, trees such as acacia (*Acacia* spp.) and mesquite (*Prosopsis glandulosa*) dominate, along with other shrub species and some grasslands. The most common grasses found include curly mesquite grass (*Hilaria belangeri*), hooded finger grass (*Chloris cucullata*), *Bouteloua* spp., and *Muhlenbergia* spp.

The structure and composition of vegetation communities strongly define ecological communities and have significant effects on ecosystem processes. Invasive plants pose one of the greatest threats to natural and cultural resources of CHDN parks. Non-native plant species are invading new areas and establishing at unprecedented rates because global trade and transportation have allowed these species to cross biogeographical barriers. Potential ecological damage from exotic, invasive species includes alteration of natural disturbance regimes and ecosystem processes, and subsequent effects on native flora and fauna. Specific concerns include threatened and endangered species sustainability, alteration of density, biomass, and diversity of native plant communities, species extirpation/extinction due to changes in fire regime, and alteration of basic soil processes. Numerous non-native plant species have been identified in CHDN park units. Saltcedar (*Tamarix* spp.), Russian olive (*Elaeagnus angustifolia*), and giant cane (*Arundo* spp.) threaten the riparian areas along the Rio Grande and other rivers. Grasslands have been invaded by Russian thistle (*Salsola* spp.), Malta starthistle (*Centaurea melitensis*), African rue (*Peganum harmala*), buffelgrass (*Pennisetum ciliare*), and others.

1.2 Program Goals and Objectives

The overall goal of the CHDN landbird monitoring program is to detect biologically significant changes in population and community parameters over time. This collaborative program is intended to maximize the strength of inferences given the available programmatic resources. The monitoring design is a multitiered, flexible framework that enables efficient estimation and monitoring of population parameters, periodic evaluation of assumptions, and the opportunity for adaptation to meet additional needs.

The CHDN selected three primary monitoring objectives, described below, that are complementary and together provide a comprehensive assessment of changes in bird populations and communities. The primary monitoring objectives focus on long-term changes and trends. Monitoring was needed for a number of years before meaningful estimates related to the objectives were feasible. As stated in our annual monitoring reports (e.g., Ali et al. 2017), it was not practical or useful to conduct comprehensive analyses for each objective on an annual basis. Instead, we provided basic data summaries each year. This report, however, contains a more comprehensive analysis that goes into much greater depth and covers all years monitored to date. It is our first such report for the CHDN landbird monitoring data.

1.2.1 Objective 1: Bird Species Richness and Composition

We estimated parameters related to community dynamics, particularly species richness and species composition. Monitoring the richness and composition of native communities, and the changes occurring within and among these communities, provides a valuable complement to population-based parameters. Species richness data are essential to understanding the effects of changing landscapes on native biodiversity. Species composition helps us to understand the effects of management and other changes by assessing which species are or are not responding to changes in the environment.

Species richness is an indicator of biodiversity and will help each park develop conservation and management plans. Annual species richness was estimated with a first order jackknife estimator to adjust raw species counts for species undetected but present (Boulinier et al. 1998, Walther and Morand 1998). This adjusted estimate is reported, as well as the original species count from the surveys; both are used to identify and investigate annual variation.

For our species composition analysis, we categorized all species observed in the parks into guilds based on preferred breeding habitat: grassland/savanna, shrubland, woodland, upland generalist, or riparian/wetland. We then analyzed breeding habitat guilds for 1) all park and habitat combinations (averaged over years), and 2) grassland (upland) and riparian habitats (averaged across parks and years). Note that the use of "grassland" and "upland" is discussed in Chapter 2, Section 2.1.1 (last two paragraphs).

1.2.2 Objective 2: Occupancy

Under this objective, we estimated the probability of occupancy in transects and points of occupied transects for as many species as possible. Occupancy indicates changes in the distribution of a species when evaluated across time. Continued advancements in occupancy theory and modeling have provided sound justification of its application in monitoring programs (MacKenzie et al. 2003, Field et al. 2005, MacKenzie et al. 2017). For monitoring occupancy, the quantitative objective of the CHDN and other SWNC networks is to "estimate the proportion of sites occupied for most species in most parks, with the goal of detecting a 3% annual decline over a 30-year period" (Beaupré et al 2013).

1.2.3 Objective 3: Density (when feasible)

We estimated density of the most common species, when possible, using the distance-sampling method at fixed points. Provided that assumptions are reasonably met, distance-sampling methods allow researchers to model a detection function that adjusts for imperfect detectability; the methods are robust and widely accepted for estimating landbird abundance (Buckland et al. 2001). For monitoring density, the quantitative objective of the CHDN and other SWNC networks is to "monitor density of the most common species, with a goal of detecting a 3% annual decline over a 30-year period (Beaupré et al. 2013).

2 Methods: Monitoring Design and Survey and Analytical Methodologies

This chapter describes the monitoring design and survey methods used to monitor landbirds in the CHDN from 2010 to 2017 (with only one park, Big Bend NP, surveyed in 2017). Design elements and methods in the CHDN are generally consistent with designs throughout the SWNC, although each member network modifies some specific elements to best address their needs. For more details on our methods than are presented here, see Powell et al. (2007) and Beaupré et al. (2013).

2.1 Spatial Sampling Designs

Our intention for monitoring landbirds extends beyond the birds themselves, and includes a broader vision of landbirds as indicators of the ecosystems they inhabit. This dual purpose influences our sampling design, especially in light of our funding and logistical limitations. In some cases, trade-offs have been made to accommodate particular habitat types or park resources that are considered particularly important to a given park.

2.1.1 Target Populations and Stratification

In NPS long-term monitoring, the target population or target universe encompasses the portion of each park to which statistical estimates of status and change will apply. Also included in this target universe are the temporal window and the portion of the landbird community to which these estimates will apply. From a spatial standpoint, landbird monitoring in the CHDN focuses on two habitat classes: grassland and riparian. Although additional habitat types exist within CHDN parks, the network's landbird monitoring prioritizes grassland and riparian bird communities as most important to monitor with available program resources. From a temporal standpoint, CHDN monitoring focuses on the breeding bird community present in these habitat classes during the spring survey window (see below). Also as seen below, in this report we present analyses focused primarily on bird species assumed to be surveyed well with standard terrestrial point-count methods. Therefore, statistical estimates presented in this report are applicable to this subset of the bird communities of grassland and riparian habitat classes during the spring breeding season.

In addition to defining the areal portion of the CHDN target universe for landbird monitoring, grassland and riparian habitat classes were also the basis for stratification. In a stratified random sample the sampling frame is divided into mutually exclusive and exhaustive strata, with samples randomly selected from each stratum (Levy and Lemeshow 1999). There are several reasons for using a stratified sampling design, including increased precision, increased efficiency, and greater information about a particular subpopulation (Cochran 1977, Lohr 1999). In cases where innately similar sampling units are considered together as a stratum, this sampling design increases sampling efficiency and precision (Thompson 2002).

With the exception of Fort Davis NHS and White Sands NP, all CHDN parks were stratified by grassland and riparian habitat classes (Table 2-1). Fort Davis NHS and White Sands NP do not contain sufficient riparian habitat to warrant a riparian transect, and therefore only the grassland class was included in the target universes of those units.

Using vegetation cover at the start of monitoring as the basis for stratification in a long-term monitoring design can be problematic because of the dynamic nature of vegetation (e.g., due to disturbances, shrub invasion, or restoration). For example, if some sites initially assigned to a grassland cover-type stratum subsequently are invaded by shrubs, while other sites outside this stratum are restored to grasslands, estimates from that stratum may have a nebulous interpretation. For the purposes of our program, we are interested in changes in grassland and riparian habitat classes, including both the current and potential states of such sites. Therefore, we defined these habitat classes as forms of ecotypes based on a combination of habitat types, soils, and general landform such that each class includes existing grassland or ri-

Table 2-1. Spatial sampling frame and methods used to designate landbird monitoring sites at CHDN parks.

Park	Strata [1]	Sample frame	Method [2]
Amistad NRA	Grassland	All Grasslands	GRTS
	Riparian	Rio Grande River	GRTS
Big Bend NP	Grassland	All Grasslands	GRTS
	Riparian	Rio Grande River, Terlingua Creek	GRTS
Carlsbad Caverns NP	Grassland	All Grasslands	GRTS
	Riparian	Rattlesnake Springs	GRTS
Fort Davis NHS	Grassland	All Grasslands	Systematic grid
Guadalupe Mountains NP	Grassland	All Grasslands	GRTS
	Riparian	McKittrick Canyon	GRTS
Rio Grande WSR	Riparian	Rio Grande River within Big Bend NP	GRTS
White Sands NP	Grassland	All Grasslands	GRTS

[1] Grassland may be referred to as upland later in this report. See explanation in Section 2.1.1.

[2] GRTS = Generalized Random-Tessellation Stratified.

parian habitat types, as well as areas that have a reasonable potential for such types either through management or natural processes (U.S. Environmental Protection Agency 2011). For example, the grassland stratum at Fort Davis NHS encompasses grasslands with scattered patches of upland scrub and woodland. This definition of habitat classes as comparable to ecotypes rather than simply current cover types is important to consider for properly interpreting results presented in this report. Many areas in our grassland habitat class are currently in shrub-dominated conditions due to historical degradation, and may not be ideal habitat for many grassland species.

In typical applications of stratification, stratum-specific estimates are produced, then combined to produce overall across-strata estimates. For analyses conducted for this report, we treat grassland and riparian habitat classes as defining two distinct areal populations of interest, rather than as a means to obtaining more precise across-habitat estimates. Analyses and estimates generally were conducted and provided separately. Because we treat grassland and riparian classes as distinct populations of interest, and because each class is more comparable to an ecotype than to a current cover class, we do the following in describing analyses and results: First, we avoid using the term "stratum" in most instances. Second, we refer to grassland and riparian classes as "upland" and "riparian" habitats, respectively. Third, we use "park-habitat" to refer to one habitat class in one park (e.g. Big Bend NP Upland, and we capitalize "Upland" or "Riparian" in this context).

2.1.2 Sampling Frame and Selection of Sampling Locations within Strata

For selecting sample locations, the sampling frame incorporates the continuous area or combination of discrete units from which locations are to be selected, along with associated information such as stratum membership. Depending on park size, CHDN used two approaches to allocate survey point locations (see Table 2-1). Sample locations were selected randomly within habitat classes using a design that creates a spatially-balanced distribution of points. Sample points in CHDN parks were located along a transect for linear features (e.g., most riparian habitats) or a grid for areal features. Note that in some cases in this report we may use the terms "transect" and "grid" interchangeably.

For the grassland (hereafter, "upland") habitat class in most CHDN parks, a 1-km^2 grid was overlaid and the centroids of grid cells made up the sampling frame. Grid cells for monitoring were then selected using Gen-

eralized Random-Tessellation Stratified sampling (GRTS; Beaupré et al. 2013), as implemented in "R" software in the "spsurvey" package. The GRTS approach is a form of spatially balanced sampling, which enables the spatial sample to reflect the spatial patterns of the population, thus leading to increased efficiency in sampling and often a lower variance (Stevens and Olsen 2004, Theobald et al. 2007).Within each grid cell selected by the GRTS algorithm, 16 points spaced 250 m apart were laid out in a grid pattern. Because of the small area encompassed by Fort Davis NHS (474 acres [192 ha]), the GRTS approach was not used. Rather, 26 sample points were placed in a grid (spaced 250 m apart) to provide coverage of the entire park unit.

As previously noted, all CHDN parks except Fort Davis NHS and White Sands NP contain adequate riparian vegetation for surveying birds. The riparian sampling frames incorporated a subset of riparian communities in most parks. Specifically, the riparian sampling frame for Amistad NRA consisted of the Rio Grande River upstream of the Amistad Reservoir. At Big Bend NP, the riparian sampling frame consisted of the Rio Grande River and Terlingua Creek. The only sampling along the Rio Grande WSR was conducted within Big Bend NP; for this reason, the remainder of the report does not specifically address the Rio Grande WSR unit. The sampling frames for Carlsbad Caverns NP and Guadalupe Mountains NP were constrained to Rattlesnake Springs and McKittrick Canyon, respectively. Note that when a sampling frame encompasses only a portion of a particular target universe, the latter effectively becomes limited to the area covered by the sampling frame. Therefore, statistical estimates presented in this report apply directly only to the areas described above. Riparian transects were selected using the GRTS algorithm in the spsurvey library for R software. Sampling points within a transect were spaced 250 m apart. Maps of the transects and grids sampled within each CHDN park are shown in Appendix A.

2.2 Temporal Sampling Designs

In CHDN, as in other SWNC networks, the overall sampling schedule is that sites are sampled every year. In large CHDN park-habitats, a hierarchical, multi-scale occupancy approach was used (Pavlacky et al. 2012, Nichols et al. 2008, Kendall and White 2009), with multiple transects selected in each park-habitat and replicate points within each transect as described above. Each of these park-habitats were visited once per year for breeding-season point-count surveys. In three small park-habitats, only one transect was selected (Carlsbad Cavern NP and Guadalupe NP riparian areas, and Fort Davis NHS, where the single upland grid covered the park). Each of these park-habitats was surveyed twice during each breeding season, following methodology of Powell et al. (2007).

With these designs, large park-habitats use spatial replication to obtain sufficient sample sizes of detections, while small park-habitats use temporal replication to compensate for the limited number of points within each of their single transects. Replicating either by space or time throughout the core breeding season ensures a greater chance of detecting all breeding birds. Visiting sites two or more times allows for more detections for estimating density; models used to estimate density are not biased by counting the same bird on consecutive counts (Buckland et al. 2001).

Combining the spatial and temporal design elements described above, we surveyed landbirds within all of the CHDN park units from 2010-2016 (except 2015). In 2017, we surveyed only within Big Bend NP. We sampled an average of 56.6 upland grids and 20 riparian transects in the CHDN each year (Table 2-2). The greatest number of upland grids was sampled in Big Bend NP, followed by White Sands NP, Guadalupe Mountains NP, and Amistad NRA. The greatest number of riparian transects was sampled in Amistad NRA and Big Bend NP. Ranges in the number of transects/grids sampled each year are also shown in the table.

2.3 Bird Surveys

2.3.1 Seasonal Timing of Surveys

During the breeding season, increased territorial behavior by songbirds results in higher detection rates and greater sampling efficien-

Table 2-2. Average number (and range) of transects or grids of each habitat class surveyed in each CHDN park per year, 2010–2016 (and 2010–2017 for Big Bend NP).

Park unit	Upland (Avg)	Riparian (Avg)	Upland (Range) [1]	Riparian (Range) [1]
Amistad NRA	8.8	9.2	8-9	8-10
Big Bend NP	19.3	8.8	17-20	5-10
Carlsbad Caverns NP	8	1 [2]	8	1
Fort Davis NHS	1 [2]	–	1	–
Guadalupe Mountains NP	9.5	1 [2]	8-10	1
White Sands NP	10	–	10	–
TOTAL OF AVERAGE	56.6	20	–	–

[1] For parks with one number (i.e., no range), the same number of transects/grids was surveyed each year.
[2] Transect/grid was surveyed twice each year.

cy. Additionally, occupancy estimates assume that a species detected is present for the entire period being surveyed. Thus, our surveys were focused on the primary breeding season in order to account for the greatest number of species in each park, recognizing that some species (e.g., migrants) may not have been adequately surveyed because of this restricted window. Although migrants are certainly an important component of bird communities, their presence can be highly variable and substantially influenced by external factors. Focusing on the breeding population is expected to provide the most reliable information about changes in bird populations related to changes in condition of CHDN parks.

The timing of breeding varies among species and depends on a number of factors, including latitude and elevation. The general window of breeding and sampling is from April through June, with adjustments for individual park visits based on park latitude and elevation. The timing of surveys by park over the entire 2010–2017 sampling period is shown in Figure 2-1. Note that the survey periods shown for each park show the earliest start date across the years and the latest end date across the years; the survey periods shown are not for any of the individual years at a given park. Surveys in a given year were conducted over a shorter period of time. As shown in the figure, surveys were generally started earlier in Big Bend NP, Fort Davis NHS, and Amistad NRA, respectively, compared to the other three parks. These parks are the southernmost in the network (see Chapter 1 for information on park locations and elevations). It is also worth noting that surveys in 2010 began (and therefore ended) relatively later in each park compared to the other years. If 2010 sampling periods were removed from Figure 2-1, the start dates would remain about the same, but the end date for each park would be approximately

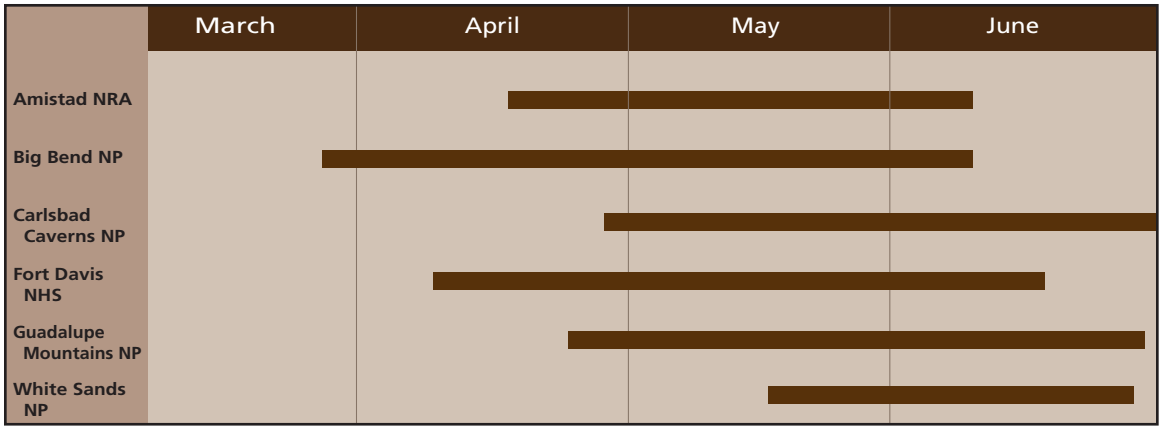


Figure 2-1. Overall period of sampling in CHDN parks from 2010–2017.

three to five weeks earlier (depending on the park).

Note that in preparing this report, we have reexamined the timing of surveys based on the survey results obtained. We discuss our findings of this reexamination in Chapter 4, Considerations for Future Monitoring.

2.3.2 Field Methodology

We used point-transect surveys to estimate and monitor landbird population parameters (Buckland et al. 2001). The point-transect approach evolved from the variable circular plot approach (Reynolds et al. 1980) and distance sampling of line transects (Burnham et al. 1980), where points are considered as a transect with zero distance (Buckland et al. 2001). For density estimates, the method involves estimating the linear distance to individual birds while standing for a predetermined period of time at a fixed point in space (Figure 2-2). For groups of birds, we measured the distance to the group and estimated the number of birds in the group.

We spent six minutes at each point along the transect or grid. Six-minute counts are consistent with region-wide bird monitoring efforts being conducted by Bird Conservancy of the Rockies (formerly Rocky Mountain Bird Observatory) and its partners, as well as with monitoring efforts by U.S. Fish and Wildlife Service (USFWS) and Tucson Audubon Society.

We recorded all birds seen or heard at each point, regardless of detection distance from the point. For most species, we recorded each individual bird as a separate observation unless groups of birds were observed at the same distance, in which case the flock or group size was noted. We considered a bird to be a "flyover" if it was flying above the top of the vegetation canopy and showing no signs of using the surrounding habitat; it was never observed foraging, displaying, or behaving in any other way that would suggest a link to the habitat below. Because these individuals were not using the habitat, we excluded flyovers from all analyses. The radial distance from the point to each bird detected during a count was measured with a laser rangefinder.

After counts were completed, observers used a handheld GPS (Global Positioning System) unit to locate successive survey points. While walking between points, observers recorded species that were not previously detected on surveys in a particular park. These observations are considered "incidental" and are treated separately from those recorded during point counts. These incidental observations allow for a more complete record of species at a site.

As described above, most CHDN transects or grids were surveyed once each year, except for the upland grid at Fort Davis NHS and the riparian transects at Carlsbad Caverns NP and Guadalupe Mountains NP, which were visited twice.

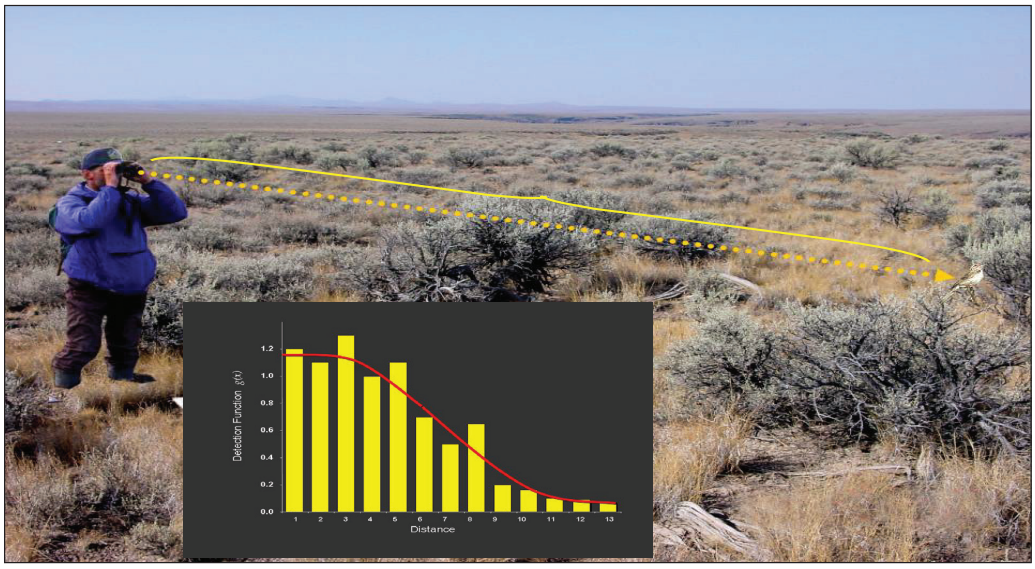


Figure 2-2. Distance sampling works by estimating a detection profile (graph) as a function of distance from which either individual or groups of birds are observed from the point.

2.4 Methods to Determine and Assess Species of Conservation Concern

This section of the report focuses on species of conservation concern that are known to breed within CHDN parks. We use the term "species of conservation concern" in a general sense, referring to species that are on a small number of federal, state, and/or organizational lists (e.g., the federal Endangered Species List, a Partners in Flight [PIF] list) that we used for this report. The term is not specifically tied to any one agency or organization.

As discussed previously, landbird monitoring in CHDN, including data management, has been conducted as part of the three-network (CHDN, SOPN, and SODN) collaboration known as SWNC. We took the overall list of species that are known to breed at one or more parks within the CHDN (Appendix B; based on expert review and the SWNC database [NPS, SWNC 2019]), and compared it to commonly used listings of species of conservation concern (described below) to identify the species of conservation concern within the network parks. The SWNC database contains the species recorded during the annual landbird monitoring in each network, in addition to other recorded species for which vetted evidence exists. Note that Appendix B indicates the CHDN parks in which each species is known to breed, as well as the parks where each species has been recorded with no evidence of breeding.

2.4.1 Species of Conservation Concern Lists

There have been a number of agencies and organizations that focus on the conservation of bird species. Such organizations may differ, however, in the criteria they use to identify and/or prioritize species of concern based on the mission and goals of their organization. They also range in geographic scale from global organizations, such as the International Union for the Conservation of Nature (IUCN), who maintains a "Red List of Threatened Species," to local organizations or chapters of larger organizations. This has been, and continues to be, a source of potential confusion for managers and others trying to make sense of and apply the applicable information. For the purposes of this report, we have focused on using species of concern lists that have associated legal mandates at federal or state levels, as well as a few listings from well-recognized sources.

The first list we used was the federal Endangered Species Act (ESA) list. The ESA, passed in 1973, is intended to protect and recover imperiled species and the ecosystems upon which they depend. It is administered by the USFWS and the Commerce Department's National Marine Fisheries Service (NMFS). The USFWS has primary responsibility for terrestrial and freshwater organisms, while the responsibilities of NMFS are mainly marine wildlife and anadromous fish. Lists of species designated as endangered or threatened or candidate for listing are available for individual states online from the USFWS website (USFWS, ECOS [Environmental Conservation Online]; USFWS 2021a). We obtained lists for both of the states within the network from this website. Note that in addition to the USFWS maintaining a list of endangered and threatened species, they maintain a list of species protected under the Migratory Bird Treaty Act (MBTA; USFWS 2020a). This Act, which protects 1,093 birds (this number is an increase from previous years), regulates "the taking, possession, transportation, sale, purchase, barter, exportation, and importation of migratory birds" (USFWS 2020b). We did not compare the list of birds known to breed within the CHDN to this extensive list (as most will be on the list), but we mention it here. A list of species protected under the MBTA can be found in the Federal Register (i.e., USFWS 2020b).

The next set of lists we used were those from the individual states within the CHDN (i.e., New Mexico and Texas). Both of these states specifically designate and protect species as threatened or endangered within the state. Citations for each listing are provided here, with full citations provided in the Literature Cited section: New Mexico Department of Game and Fish (NMDGF; 2020); and Texas Parks and Wildlife (TPW; 2020).

The third listing we used to identify species of conservation concern within the CHDN

was one used by NatureServe (NatureServe 2020). NatureServe ranks species globally and by state, and we used the global rankings for our list of species of conservation concern. The SWNC database includes these global rankings for each species recorded within the CHDN, and for this report we included those species having a ranking of G1 to G3 (out of G1 to G5). Each of the three rankings we used are defined as follows: G1(critically imperiled—at very high risk of extinction due to extreme rarity, very steep declines, or other factors); G2 (imperiled—at high risk of extinction due to very restricted range, very few populations, steep declines, or other factors); and G3 (vulnerable—at moderate risk of extinction due to a restricted range, relatively few populations, recent and widespread declines, or other factors; NatureServe 2020).

The next listing of species of conservation concern we used for the CHDN was from Partners in Flight (PIF). Partners in Flight is a cooperative effort among federal, state, and local government agencies, as well as private organizations. One of its primary goals, relative to listing species of conservation concern, is to develop a scientifically based process for identifying and finding solutions to risks and threats to landbird populations. Their approach to identifying and assessing species of conservation concern is based on biological criteria to evaluate different components of vulnerability (Panjabi et al. 2019). Each species is evaluated for six components of vulnerability: population size, breeding distribution, non-breeding distribution, threats to breeding, threats to non-breeding, and population trend. The specific process is presented in detail in the species assessment handbook (Panjabi et al. 2019).

The PIF assessments are conducted at multiple scales. At the broadest scale, the North American Landbird Conservation Plan (Rich et al. 2004) identifies what PIF considers "Continental Watch List Species" and "Continental Stewardship Species." Continental Watch List Species, which is the group we chose to consider for our CHDN list, are those that are most vulnerable at the continental (range-wide) scale due to a combination of small and declining populations, limited distributions, and high threats throughout their ranges (Panjabi et al. 2019).

The final list we used to compile species of conservation concern in the CHDN was the list from the New Mexico Avian Conservation Partners (NMACP). The NMACP is a state chapter of PIF (formerly the New Mexico Partners in Flight). This state chapter, which was established in 1995, serves to promote the conservation and management of New Mexico birds and their habitats (NMACP 2017a). New Mexico Avian Conservation Partners considers species as Level 1 or Level 2, with Level 1 species having higher assessment scores (and therefore being more vulnerable; NMACP 2017b). We used only the Level 1 species for our list for CHDN.

2.4.2 Breeding Habitat Availability for Species of Conservation Concern

Once we obtained a list of species of conservation concern for the network (based on the lists and criteria we used), we refined the list for each park to include just those species that are known to breed in each park. We then estimated, qualitatively, the level or extent of breeding habitat available in a given park for each species. Again, we excluded species from this assessment for a given park if they were not known to breed there.

Species were designated as breeders (i.e., evidence of breeding exists) or non-breeders (i.e., no evidence of breeding exists, but breeding is possible) based on the SWNC database (NPS, SWNC 2019). However, we reviewed the SWNC list regarding breeding and made some revisions based on professional knowledge/experience and the resources listed in Appendix B; these include: New Mexico Ornithological Society database (2019), eBird (Sullivan et al. 2009), NPS CHDN database, Billerman et al. (2019), and NPSpecies database (NPS 2019).

We assigned a habitat availability class to each breeding landbird species in a given park. Eight habitat availability classes, defined by us for this report, were used: extensive, moderate, limited, reduced, historic, possible, none, or unknown (Table 2-3). The first three classes were used most often. Habitat avail-

ability classes were assigned for each species/park by individuals knowledgeable about the species, habitat required for breeding, and individual parks (Table 2-4).

2.5 Analytical Methodology

2.5.1 Species Richness

Species richness, the number of species in an area, is one way to measure and track biodiversity. To determine species richness of birds in upland and riparian habitats in parks, the monitoring program annually surveyed designated sample areas using point counts. The landbird surveys provide a raw species count based on what was observed and recorded. However, the raw count is not the best representation of species richness. At the spatial scale of this monitoring program, completely surveying most park-habitats is infeasible. Moreover, not all species present on survey sites may be detected. However, models can be used to estimate species richness for each park-habitat within an acceptable level of error (Bibby et al. 2000, Gotelli and Colwell 2011).

The overall method we used to estimate species richness was based on closed-population mark-recapture abundance estimation, but instead of abundance of a single species we applied the model at a larger scale to estimate the number of species in a community (Burnham and Overton 1979, Boulinier et al. 1998). Closed-population mark-recapture abundance estimation is based on repeated observation, either over time or space. The replicates in our model were spatial replicates, either at the point or transect level (based on park size), with larger units using transects and smaller units (or park-habitats) using points (Table 2-5). Some park units (Fort Davis NHS) and park-habitat combinations (Carlsbad Caverns NP Riparian, Guadalupe Mountains NP Riparian) had temporal repetition within a year to obtain a larger sampling effort; we added these repeated visits together for one list of presence/absence per survey location per year. We

Table 2-3. Breeding habitat availability classes.

Habitat Availability Class	Class Description
Extensive	Breeding habitat is common to abundant in the park.
Moderate	Substantial breeding habitat exists in the park.
Limited	Small area(s) of breeding habitat exist in the park.
Reduced	Small area(s) of breeding habitat exist in the park, but historically habitat was moderate to extensive.
Historic	Breeding habitat existed historically in the park, but no longer does.
Possible	Breeding habitat is marginal in quality and/or its presence is uncertain.
None	Breeding habitat does not exist in the park and never has.
Unknown	Knowledge insufficient to categorize.

Table 2-4. Experts who determined breeding habitat availability, by park.

Park	Expert
Amistad NRA	Sarah Howard, Biologist, Amistad NRA
Big Bend NP	David Larsen, Superintendent, Fort Davis NHS
Carlsbad Caverns NP	Steve West, Biologist with extensive experience with the birds and habitats at Carlsbad Caverns NP
Fort Davis NHS, Guadalupe Mountains NP	Kelly Bryan, Biologist, Davis Mountains State Park (retired) and Master Bander
White Sands NP	David Bustos, Chief of Natural and Cultural Resource Management, White Sands NP

converted the raw data into an incidence encounter history matrix, where each column was a replicate, and each row represented a species. An observation of a species at a point or transect was equivalent to a "capture" and was represented by a "1." If the species was not observed at the point or transect, then it was considered "not captured" and was represented by a "0." This procedure created an incidence encounter history for each species, which we then used in a first-order jackknife model to estimate species richness for each combination of year, habitat type, and park.

The first-order jackknife estimator created an adjusted species richness estimate using a different detection probability for each species, and accounted for undetected but present species by correcting based on species observed only once (Boulinier et al. 1998, Burnham and Overton 1979). The jackknife estimator has often been recommended for use when detection probability varies among species and with environmental gradients, which is beneficial given the variable detection of bird species and the various habitats surveyed as a part of this monitoring program (Boulinier et al. 1998, Burnham and Overton 1979, Gotelli and Colwell 2011). Although this estimator's performance can vary widely depending on sample sizes, sampling effectiveness, and underlying patterns of true species richness, we assumed we were applying the first-order jackknife under conditions in which it typically has acceptably low bias (Walther and Morand 1998, Chiu et al. 2014). In particular, we obtained large sample sizes of detections at large parks and had high spatial coverage of small parks. Richness estimates from the first-order jackknife appeared reasonable given the previously documented potential species pool for each park, particularly for the subset of species known to be surveyed adequately with diurnal point counts.

We used the package "SpadeR" (Chao et al. 2016) in R (R Core Team 2019) for our analysis. Richness estimates from multiple estimators available in this package were examined, but only the first-order jackknife estimator is reported here (Chao et al. 2016). SpadeR automatically bounds the lower limit of the confidence interval to be equal to or greater than the observed raw species richness (Chao et al. 2016).

Table 2-5. Species richness replicate scale for analysis of park units. Analysis was conducted at the point level for small parks/park-habitats with one transect, and the transect level for larger parks/park-habitats.

Park Unit	Habitat	Scale
Carlsbad Caverns NP	Riparian	Point*
Guadalupe Mountains NP	Riparian	Point*
Fort Davis NHS	Upland	Point*
Amistad NRA	Upland	Transect
Amistad NRA	Riparian	Transect
Big Bend NP	Upland	Transect
Big Bend NP	Riparian	Transect
Carlsbad Caverns NP	Upland	Transect
Guadalupe Mountains NP	Upland	Transect
White Sands NP	Upland	Transect

* Park-habitats using the point scale had temporal repetition within a year. Repeated observations within a year were combined for a larger annual sample size.

We ran three different data subsets through SpadeR. The first run was all species with only incomplete data removed, which provided annual species richness estimates for entire bird communities in each park and habitat type. The second run was the complete dataset with only known regular and irregular breeders, with possible breeders and non-breeders removed. Breeding status was investigated and defined for this analysis (see Appendix B). Surveys had inconsistency in timing each year, meaning migrants and changes in breeders throughout the entire season could influence species richness estimates (Best 1981, Ralph et al. 1993, Ralph et al. 1995). We minimized this variability in our second and third runs by including only regular and irregular breeders.

The third (most restricted) run included only birds that are well-surveyed by point counts. Detectability of some groups of birds is poor with point-count methodology (Ralph et al. 1993). The groups we excluded were secretive nesters, low-density breeders, and nocturnal and colonial species (Bibby et al. 2000, Sutherland et al. 2004, Ralph et al. 1995). This restricted the analysis to birds that are

accurately represented by point counts, and thus prevented related bias in the jackknife estimator. Note that in the main report we present only the estimates of breeding species well-surveyed by point counts. Results from the first two runs are presented in Appendix C.

In addition to species richness, we analyzed species composition. We designated all species observed in the park units with a preferred breeding habitat: grassland/savanna, shrubland, woodland, upland generalist, or riparian/wetland (Table 2-6). We first analyzed these breeding habitat guilds for all park unit and habitat combinations. We totaled the number of species in each breeding habitat guild for each year. Then we calculated the species in each guild over the yearly total species in all guilds to estimate the annual species proportion of each guild. We averaged the proportions over years (n), and reported the across-years average. We calculated the standard deviation using the annual proportions. The second species composition analysis was similar to the first analysis, but proportion was averaged across parks and years to obtain guild proportions within sampled upland and riparian habitats.

2.5.2 Occupancy Modeling

We estimated park-habitat-level occupancy parameters using Bayesian hierarchical, single-species, dynamic occupancy models (Pavlacky et al. 2012, MacKenzie et al. 2017, Green et al. 2019). We conducted separate analyses for upland and riparian habitats, but for each habitat we integrated all parks into one mixed-effects model analysis per species because of the low number of transects in many park-habitat combinations. We conducted analyses for each species-habitat combination that met the following criteria: a) 20 or more point detections combined across all years and parks, and b) at least 10 detections in one or more parks. We included any additional species not meeting the above criteria but with >10 point detections (combined across years) for at least one park in that habitat. Additional species not meeting these thresholds were analyzed but consistently failed to produce usable results.

For both habitats, the CHDN sampling designs included 1) parks with single transects and two visits to the transects each sampling year (Fort Davis NHS Upland, Carlsbad Caverns NP and Guadalupe Mountains NP Riparian), and 2) parks with multiple transects, following Pavlacky et al.'s (2012) two-level design, and a single visit per year. For each habitat, we integrated these designs into a single analysis, with each six-minute point-count survey broken into three two-minute intervals to provide temporal replication for modeling detection probability (see below). Thus, for an individual species and habitat, each row of the input data consisted of the encounter history for one point-year combination, along with the park, year, transect, and point identities for that row. To allow both the one-visit- and two-visits-per-year park-habitat combinations to be included in the same data file, the encounter history was of length 6 (3 intervals per visit x 2 visits), but with missing data ("NA") for the second set of three intervals for park-habitats with only one visit. For the park-habitats with multiple visits within a year, revisits frequently occurred at short intervals, and we assumed closure of occupancy across those visits (e.g., that a point's occupancy status did not change between visits within the year). If there were no detections of a species in a particular park unit across any years of sampling, occupancy probability for that park was fixed at zero.

In the Pavlacky et al. (2012) design, occupancy probabilities include transect-level occupancy (i.e., the probability any part of the transect was occupied that year), conditional point-level occupancy (i.e., the probability a point was occupied conditional on it being part of an occupied transect), and unconditional point-level occupancy (i.e., transect-level occupancy probability x conditional point-level occupancy). Integrating park-habitats that used the Pavlacky hierarchical design and park-habitats with only one level of sampling and/or one transect into a single analysis required ensuring that both types of designs were handled by a single overall Bayesian model, with transect occupancy and conditional point occupancy parameters defined for all park-habitats. For park-habitat combinations with only one transect (e.g., a single grid covering an en-

Table 2-6. Common name and breeding habitat guild of species included in our species richness analysis. Species listed are those that breed in the CHDN, except for those expected to be poorly represented by our sampling methods (i.e., nocturnal, colonial, and waterbird species, Galliformes, and/or those that occur in low densities).

Common Name	Breeding Habitat Guild *
Acorn Woodpecker	W
American Robin	UG
Ash-throated Flycatcher	UG
Band-tailed Pigeon	W
Barn Swallow	UG
Bell's Vireo	RW, S
Bewick's Wren	W
Black Phoebe	RW
Black-capped Vireo	S
Black-chinned Hummingbird	W
Black-chinned Sparrow	S, GS
Black-crested Titmouse	W
Black-headed Grosbeak	W
Black-tailed Gnatcatcher	S
Black-throated Gray Warbler	W
Black-throated Sparrow	S
Blue Grosbeak	GS
Blue-gray Gnatcatcher	W
Blue-throated Mountain-gem	W
Broad-tailed Hummingbird	W
Bronzed Cowbird	UG
Brown Creeper	W
Brown-crested Flycatcher	S
Brown-headed Cowbird	UG
Bullock's Oriole	RW
Bushtit	W
Cactus Wren	S, GS
Canyon Towhee	S
Canyon Wren	UG
Carolina Wren	RW
Cassin's Kingbird	W, RW
Cassin's Sparrow	GS, S
Cave Swallow	UG
Chihuahuan Raven	GS, S
Cliff Swallow	RW
Colima Warbler	W

Common Name	Breeding Habitat Guild *
Common Ground Dove	S, RW
Common Raven	UG
Common Yellowthroat	RW
Cordilleran Flycatcher	W
Couch's Kingbird	UG
Crissal Thrasher	S
Curve-billed Thrasher	S
Dark-eyed Junco	W
Dusky-capped Flycatcher	W
Eastern Bluebird	W
Eastern Meadowlark	GS
Eastern Phoebe	RW
Eurasian Collared-Dove	UG
European Starling	UG
Golden-fronted Woodpecker	W
Grace's Warbler	W
Gray Flycatcher	W
Gray Vireo	W
Greater Roadrunner	S
Great-tailed Grackle	UG
Groove-billed Ani	UG
Hairy Woodpecker	W
Hepatic Tanager	W
Hermit Thrush	W
Hooded Oriole	W
Horned Lark	GS, S
House Finch	UG
House Sparrow	UG
House Wren	UG
Hutton's Vireo	W
Inca Dove	S
Indigo Bunting	RW
Juniper Titmouse	W
Ladder-backed Woodpecker	S
Lark Sparrow	GS, S
Lesser Goldfinch	W, S

* In cells with two guilds, the first is the primary and the second is the secondary guild; only the primary guild is mentioned in the report text. GS = Grassland/Savanna; S = Shrubland; RW = Riparian/Wetland; UG = Upland Generalist; W = Woodland (includes pinyon-juniper & other open woodland types).

Table 2-6, cont. Common name and breeding habitat guild of species included in our species richness analysis. Species listed are those that breed in the CHDN, except for those expected to be poorly represented by our sampling methods (i.e., nocturnal, colonial, and waterbird species, Galliformes, and/or those that occur in low densities).

Common Name	Breeding Habitat Guild *
Loggerhead Shrike	GS, S
Lucifer Hummingbird	S
Lucy's Warbler	S
Mexican Jay	W
Mountain Chickadee	W
Mourning Dove	UG
Northern Cardinal	RW
Northern Flicker	W
Northern Mockingbird	UG
Northern Rough-winged Swallow	RW
Olive-sided Flycatcher	W
Orange-crowned Warbler	S, W
Orchard Oriole	W
Painted Bunting	RW, S
Painted Redstart	W
Phainopepla	S
Pine Siskin	W
Plumbeous Vireo	W
Purple Martin	W
Pygmy Nuthatch	W
Pyrrhuloxia	S, RW
Red Crossbill	W
Red-breasted Nuthatch	W
Red-winged Blackbird	RW
Rivoli's Hummingbird	W
Rock Pigeon	UG
Rock Wren	S
Rufous-crowned Sparrow	S
Say's Phoebe	S, GS
Scissor-tailed Flycatcher	GS
Scott's Oriole	S
Song Sparrow	RW
Spotted Towhee	W, S
Steller's Jay	W
Summer Tanager	RW, W
Thick-billed Kingbird	RW, W
Tropical Kingbird	S
Varied Bunting	S
Verdin	S
Vermilion Flycatcher	RW, S
Violet-green Swallow	W
Virginia's Warbler	W
Warbling Vireo	W
Western Bluebird	UG
Western Kingbird	UG
Western Meadowlark	GS
Western Tanager	W
Western Wood-Pewee	W
White-breasted Nuthatch	W
White-throated Swift	UG
White-winged Dove	W, S
Willow Flycatcher	RW
Woodhouse's Scrub-Jay	W
Yellow Warbler	RW
Yellow-billed Cuckoo	RW
Yellow-breasted Chat	RW
Yellow-rumped Warbler	W

* In cells with two guilds, the first is the primary and the second is the secondary guild; only the primary guild is mentioned in the report text. GS = Grassland/Savanna; S = Shrubland; RW = Riparian/Wetland; UG = Upland Generalist; W = Woodland (includes pinyon-juniper & other open woodland types).

tire small park), we fixed transect occupancy each year to 1.0 so the resulting "conditional" point-occupancy estimates were actually estimates of unconditional point-level occupancy for those park-habitats, just as would be estimated if each of these park-habitats were analyzed individually using the standard occupancy model for non-hierarchical designs.

Similar to Green et al. (2019), we modeled transect-scale occupancy dynamics explicitly, such that the transect-level occupancy parameters included initial occupancy in the

first year of the data set, yearly transect-scale extinction probability, and yearly transect-scale colonization probability (i.e., Psi1() gamma()epsilon() parameterization). Initial pilot modeling indicated that data were insufficient for estimating temporal variation in gamma or epsilon, as data sets to date had spanned only five to seven years and were based on a low sample size of transects in most park-habitat combinations. Therefore, we estimated park-specific fixed-effects values of initial transect occupancy probability, gamma and epsilon, with the latter two dynamic parameters assumed constant across transects and years for a given park. We modeled point-scale occupancy conditional on transect occupancy, with only implicit dynamics modeled at the point scale (i.e., point occupancy was estimated for each year without consideration of previous year's occupancy for each point). Conditional point occupancy for upland analyses was a function of a global intercept and random effects of park, year, park-year, and transect-year. For riparian analyses, which had a much lower sample size of transects, we simplified the point occupancy parameterization to a fixed effect of park, with random effects of park-year and transect-year.

For our occupancy analysis, we modeled detection probability using a removal model. Each 2-minute interval within a single point count was treated as a replicate survey, as is standard in single-visit point-count occupancy analyses. We summarized species binary detection status (detected, not detected) for each interval per point visit. Because the field methodology did not allow for the recording of reobservations of the same individual within a single point count, we used a removal-model formulation that only considered intervals up to and including the first interval with a detection of the species during that point-count survey. Variability in detection probability was modeled as a function of an intercept plus a park-year random effect. We modeled all occupancy and detectability parameters on the logit scale.

We conducted the analyses with program "JAGS" (Plummer 2017) through R package "rjags" (Plummer et al. 2019), using Markov chain Monte Carlo (MCMC) to estimate posterior distributions for model parameters. For each analysis, we ran three MCMC chains and evaluated convergence with the Gelman-Rubin statistic. The MCMC analyses included an adaptive phase of 10,000–50,000 iterations, an updating phase of 20,000 to 200,000+ iterations, and post-convergence sampling of 20,000 to 50,000+ iterations, with data sparsity and ease of convergence affecting the number of iterations at each phase as we monitored convergence for each species. Prior distributions included non-informative [Uniform(0,1)] intercept parameters on the probability scale. Random effects logit-scale variance parameters used half-normal (positive only) distributions. We specified the scale parameters to be weakly informative to avoid sampling extremely high values in the prior distributions (tau scale parameter ranging from 0.01 to 0.25). Posterior distributions were formed for derived parameters, including overall average transect and point occupancy for each park-habitat-species combination across years. For each park-habitat combination, we report occupancy estimates only for species with at least 10 point detections combined across years. We report the median of the estimated posterior distribution and 95% credible intervals for occupancy parameters. We report average *transect* occupancy estimates with a coefficient of variation of 50% or less. For park-habitats with single transects (Fort Davis NHS Upland, Carlsbad Caverns NP and Guadalupe NP Riparian), we report average *point* occupancy estimates with a 50% or lower coefficient of variation. We report results for regular and irregular breeding species that are well-surveyed by point counts.

2.5.3 Density Estimation

Density is defined as the number of birds present per area surveyed. We produced density estimates for each species-park-habitat. We used R packages "Distance" and "mrds" (Miller 2017, Laake et al. 2018, Rosenstock et al. 2002) for all analyses.

Distance sampling and associated statistical analyses use the detection distances of observed birds to model probability of detection during a survey as a function of distance from the point location (Buckland et al. 2001). [Powell and Gale (2015) provide an introduction to the topic accessible to

most biologists.] The raw observed count and the detection probabilities of individuals within a species are used to estimate the actual number of birds present in the plot, thus correcting for incomplete and variable detection probability (Rosenstock et al. 2002). For analysis, we treated distances as continuous and truncated the furthest 10% of detections for each species-park-habitat combination (Buckland et al. 1993).

Modeling the detection function requires a minimum raw count for reliable estimation of detection probability; our raw count was based on cluster detections. Buckland et al. (2001) recommend having at least 75 to 100 detections when analyzing with cluster detections. The different number of individuals in each cluster introduces additional variance that is balanced by using a larger sample size (Buckland et al. 1993). Therefore, we limited analyses to species that had at least 100 detections combined across years for each park and habitat combination. We estimated the total individual density by multiplying the average cluster size and the estimated density of clusters. We pooled detections at each point per year for park-habitats with only one transect (pooled temporal repetition; see Table 2-5). For parks with multiple transects, we pooled points within transects (pooled spatial repetition). In both cases we used the number of point visits to calculate yearly effort at the point or transect scale.

In addition, we considered that detectability relationships could vary spatially and temporally among species, parks, and general cover types within parks. Therefore, we conducted separate analyses for each species, park, and habitat (upland, riparian) combination that had at least 100 cluster detections, with selection of a model and estimation of density done separately for each combination. We used a data-driven approach and model selection to select among five model options (Table 2-7). We used three key function shapes to suit the relationship between detection probability and distance to develop a detection probability function. Additional terms were automatically chosen for the three key functions through series adjustment to adjust the detection probability function. For these three models, we assumed a common detection function across all years. For two additional models, we added "year" as a covariate to allow for changes in the detection probability function scale among years. We ran the five key function and adjustment term combinations for each species, park, and habitat combination (see Table 2-7). We used Akaike Information Criterion (AIC) to identify the top models and the Cramer-von Mises goodness-of-fit test to assess fit of each model (Akaike 1998). The yearly scales adjustment terms performed poorly for years of low sample sizes; therefore, we assessed models and made decisions about pooling some years. We then manually selected the final model for each combination based on the best AIC score, goodness-of-fit tests, and examination of output. All density estimates in this report are based on the best model for each species, park, and habitat combination, and results are reported for regular and irregular breeding species well-surveyed by point counts.

Table 2-7. The five density models (including key functions and adjustment terms) used to obtain estimates.

Density Model #	Key Function [1]	Adjustment Terms [2]
1	Uniform	Series Adjustment [3]
2	Hazard	Series Adjustment [3]
3	Half-Normal	Series Adjustment [3]
4	Hazard	Yearly Scale [4]
5	Half-Normal	Yearly Scale [4]

[1] Key function describes the general detection probability shape.

[2] Adjustment terms are slight changes made to the shape.

[3] Series adjustments are done automatically in the package.

[4] Yearly scale adjustment allows the curve to adjust slightly to better fit the relationship between distance and detection probability per year, while retaining the main shape of the key function.

3 Results and Discussion

3.1 Species of Conservation Concern

This section of the report focuses on species of conservation concern (SCC) that breed or have been known to breed within CHDN parks. Our methods for the results presented in this section were described in Section 2.4 of the report. Note that scientific names of species mentioned in the report can be found in Appendix B.

3.1.1 Species of Conservation Concern within CHDN

Of the species known to breed in at least one park in the CHDN, 23 are listed on one or more of the species of conservation concern lists we reviewed for this report. Most of the 23 species appear on only one or two of the five listings we used, while one species appears on three to five of the listings (i.e., Mexican Spotted Owl; Table 3-1). The Mexican Spotted Owl (a subspecies of Spotted Owl), and subspecies of Willow Flycatcher and Yellow-billed Cuckoo are federally listed (see the table and table notes for more detail). Eleven of the species are state-listed, but again, some listings may apply only to subspecies that may or may not be known to occur in the parks. Four of the species have NatureServe ranks of G3 or G3G4. Thirteen species are listed by PIF as continental watch list species, and six species are Level 1 species with NMACP.

Table 3-1 also shows the parks in which each of the 23 SCC is known to breed (designated with a "+"). If a species of conservation concern was known to breed in at least one park, we also noted in which parks it has been recorded but breeding has yet to be confirmed. Overall, these species are known to breed in from one to six parks within the CHDN. Scaled Quail, for example, breeds in all six parks (Figure 3-1).

Note that in some cases a species appears in the table but was only state-listed in one of the two states in the network. In these cases, we note its breeding status in the other state/parks, but it is not considered a SCC in those parks (at least based on the five lists we used). This is the case, for example, for Bell's Vireo, which is known to breed in both Texas and New Mexico parks, but it is only state-listed in New Mexico.

There are five additional species that did not meet our criteria to list in the table but which should be mentioned. These are Common Ground Dove, Juniper Titmouse, Neotropic Cormorant, Thick-billed Kingbird, and Woodhouse's Scrub-Jay. All five species appear only on one of the two SCC lists specific to New Mexico (i.e., either state threatened/endangered or NMACP Level 1). None of the species are known to breed in the two New Mexico parks, but all of the five species have been documented to breed in one or two of the parks in Texas (see Appendix B for details). Also note that we included Least Tern in Table 3-1 and the next table because it was just recently federally (and Texas) delisted .

It is also worth noting that two species/subspecies that are federally listed are known to occur (or have been recorded) in the CHDN but are not known to breed there. The first species is the Golden-cheeked Warbler, which is listed as endangered by the USFWS and State of Texas. In the CHDN, this species has been recorded only in Big Bend NP. The



Figure 3-1. Scaled Quail, listed by PIF and NMACP, has been documented to breed in all six CHDN parks. Photo: © MOEZ ALI

Table 3-1. Landbird species known to breed in the CHDN that are considered species of conservation concern (SCC) according to one or more of five SCC lists. Whether species are known to breed in a particular park (+), or known to occur with no evidence of breeding (o), is also shown. A table cell with an "X" indicates the species occurs on that list.

Common Name	SCC Lists					CHDN Parks in which Recorded [1]					
	Federal List & Status [2]	G Rank [3]	State List & Status [4]	PIF [5]	NMACP [6] Level 1	AMIS	BIBE	CAVE	FODA	GUMO	WHSA
Band-tailed Pigeon	–	–	–	X	–	–	+	o	–	+	–
Bell's Vireo	–	–	NM: T	–	–	+	+	+	o	o	o
Black-capped Vireo	X [7]	G3	X [7]	X	–	+	+	o	–	–	–
Black-chinned Sparrow	–	–	–	X	–	o	+	+	+	+	o
Colima Warbler	–	G3G4	–	X	–	–	+	–	–	o	–
Common Black-Hawk	–	–	NM: T; TX: T	–	–	o	+	+	o	o	–
Flammulated Owl	–	–	–	X	X	–	+	o	o	+	–
Grace's Warbler	–	–	–	X	X	–	o	o	–	+	–
Gray Hawk	–	–	TX: T	–	–	–	+	+	o	–	–
Gray Vireo	–	–	NM: T	X	–	o	+	+	–	+	o
Least Tern	X [8]	–	NM: E	–	–	+	o	–	–	–	o
Lucifer Hummingbird	–	–	NM: T	X	–	–	+	o	–	o	–
Mexican Spotted Owl	T	G3G4	TX: T	X [9]	X [9]	–	–	o	–	+	–
Mexican Whip-poor-will	–	–	–	X	X	–	+	o	–	+	–
Olive-sided Flycatcher	–	–	–	X	–	o	o	o	o	+	o
Peregrine Falcon	–	–	NM: T; TX: T [10]	–	–	o	+	o	–	+	o
Scaled Quail	–	–	–	X	X	+	+	+	+	+	+
Snowy Plover	–	G3	–	–	–	+	–	–	–	–	+
Varied Bunting	–	–	NM: T	–	–	+	+	+	o	o [11]	–
Virginia's Warbler	–	–	–	X	X	–	o	o	o	+	o
Willow Flycatcher	E [12]	–	NM: E [12] TX: E [12]	–	–	–	o	+	–	o	–
Yellow-billed Cuckoo	T [13]	–	–	–	–	+ [14]	+	+	o	+	–
Zone-tailed Hawk	–	–	TX: T	–	–	o	+	o	o	o	–

[1] Park acronyms—AMIS = Amistad NRA, BIBE = Big Bend NP, CAVE = Carlsbad Caverns NP, FODA = Fort Davis NHP, GUMO = Guadalupe Mountains NP, WHSA = White Sands NP.

[2] Federal list according to USFWS: T = Threatened, E = Endangered.

[3] G Rank according to NatureServe (and obtained from the SWNC database). G3 = vulnerable: at moderate risk of extinction due to a restricted range, relatively few populations, recent and widespread declines, or other factors (NatureServe 2020). G3G4 = A range from G3 to G4; indicates uncertainty about exact status. G4 = apparently secure: at fairly low risk of extinction or elimination due to an extensive range and/or many occurrences or populations, but with possible cause for some concern (NatureServe 2020).

[4] State list and status: NM = New Mexico, TX = Texas. T = Threatened, E = Endangered.

[5] PIF = Partners in Flight. The PIF list we used contained only Continental Watch List species (Rosenberg et al. 2016).

[6] NMACP = New Mexico Avian Conservation Partners. We used only the Level-1 species from NMACP (out of two levels).

[7] Species was federally delisted in April 2018 (USFWS 2018) and state (Texas) delisted in 2020 (TPW 2020).

[8] Only the interior population (that is, Interior Least Tern) was federally listed and state listed in Texas. The interior population is known to occur and breed in AMIS (NPS CHDN 2010, Valentine-Darby et al. 2016), and known to occur at BIBE and WHSA. The Interior Least Tern was federally delisted in February 2021 (USFWS 2021b), and the state of Texas delisted it as well.

Table 3-1 notes continued...

[9] Listing is for the species (Spotted Owl), not specifically the subspecies.

[10] anatum subspecies.

[11] historic breeder.

[12] Only the Southwestern Willow Flycatcher is listed (Empidonax traillii extimus). The subspecies has been recorded breeding in CAVE. Both BIBE and GUMO are within the historic breeding range of the subspecies, but no breeding has been recorded there.

[13] Listing is for the Western U.S. Distinct Population Segment only (subspecies occidentalis). According to a range map from USFWS, the DPS appears to occur in the vicinity of BIBE, CAVE, FODA, and GUMO, but not immediately near AMIS (USFWS 2017b); also see note below.

[14] The Yellow-billed Cuckoos at AMIS are not the western subspecies (USFWS 2014). For this reason, we did not include them in Table 3-2 for AMIS.

second species is the Northern Aplomado Falcon. This subspecies is listed as endangered by the USFWS and both New Mexico and Texas. The USFWS (2017a) indicates that the subspecies may occur in a portion of Texas that includes Big Bend NP and Guadalupe Mountains NP. Banded individuals, believed to be part of a USFWS captive release program, have been recorded at Big Bend NP (Raymond Skiles, BIBE, pers. comm.). There is no evidence of the subspecies breeding in Big Bend NP or elsewhere in the network. The falcon has also been recorded as an accidental occurrence at Guadalupe Mountains NP (see Appendix B).

3.1.2 Habitat Availability Assessment for SCC

Using the approach described in Section 2.4.2, we assessed whether parks where a given species was known to breed have extensive, moderate, limited, reduced, historic, possible, none, or unknown breeding habitat availability for the species. Here, we present results of this assessment by park (Table 3-2) and by species (Table 3-3). For the table organized by species, we included only those having extensive and/or moderate habitat availability to emphasize situations that represent relatively low-cost opportunities to stabilize or restore declining populations.

Amistad NRA has four breeding SCC, with two species in the extensive habitat availability class, one in the moderate class, and one in the limited class (Table 3-2). Big Bend NP has 14 breeding SCC, with one species in the extensive habitat availability class, three in the moderate class, and 10 in the limited class. Carlsbad Caverns NP has eight breeding SCC, with three in the extensive class, two in the moderate class, and three in the limited class. Two breeding SCC occur at Fort Davis NHP, with both falling into the moderate class. At Guadalupe NP, 12 breeding SCC occur; five of them fall into the extensive class, three of them fall into the moderate class, and four fall into the limited class. Finally, White Sands NP has two breeding SCC; one falls into the extensive habitat availability class, and one falls into the possible class (with breeding habitat of marginal quality).

As noted above, our table by species (i.e., Table 3-3) includes only those with at least moderate or extensive habitat availability. Table 3-3 includes 15 species. For most of the species, moderate or extensive habitat is available only at one park per species. However, two species, Black-chinned Sparrow and Scaled Quail, have four and six parks, respectively, with this level of breeding habitat available to them.

In summary, of the 23 SCC known to breed within the CHDN, 15 species have at least one park in the network with a moderate or extensive level of breeding habitat available.

Table 3-2. Habitat availability classes assigned to each species of conservation concern at CHDN parks. Information is shown only for species/parks designated with "+" in Table 3-1 (i.e., those species known to breed in the park).

Parks where Breed	Species	Habitat Availability*	Notes
Amistad NRA	Black-capped Vireo	Limited	–
	Least Tern (Interior)	Extensive	–
	Scaled Quail	Extensive	–
	Snowy Plover	Moderate	–
Big Bend NP	Band-tailed Pigeon	Limited	Species observed in Chisos Mountains. Species usually observed post breeding season above 5,500 ft.
	Black-capped Vireo	Moderate	Occupies territories between about 3,500 and 5,500 ft in drainages surrounding and in the Chisos Mountains.
	Black-chinned Sparrow	Moderate	Occupies habitats above 4,000 ft in the Chisos Mountains. Prefers open shrublands/woodlands on slopes of the Chisos Mountains.
	Colima Warbler	Limited	Species limited to drainages/canyons above 5,500 ft in the Chisos Mountains.
	Common Black-Hawk	Limited	Breeding territories are limited to cottonwood stands at two developed areas and along a limited number of drainages.
	Flammulated Owl	Limited	Species has been detected above 6,000 ft in the Chisos Mountains, primarily in canyons with large trees. Very limited habitat in the Chisos Mountains.
	Gray Hawk	Limited	Breeding territories are limited to cottonwood stands at two developed areas and along a limited number of drainages.
	Gray Vireo	Limited	Breeds in open scrub/woodlands. Species considered uncommon/ rare.
	Lucifer Hummingbird	Moderate	Breeds in drainages/canyons surrounding the Chisos Mountains from 3,500 to 6,000 ft.
	Mexican Whip-poor-will	Limited	Breeds above 5,500 ft in the Chisos Mountains.
	Peregrine Falcon	Moderate	Approximately 10 known nesting areas in the park.
	Scaled Quail	Extensive	Found in low desert to upper desert grassland elevations into lower Chisos Mountains.
	Yellow-billed Cuckoo	Limited	Riparian bosque habitat along the Rio Grande. Detected in riparian corridors from Castolon area to Rio Grande Village.
	Zone-tailed Hawk	Limited	Breeding territories are limited to cottonwood stands at two developed areas and along a limited number of drainages.
Carlsbad Caverns NP	Bell's Vireo	Limited	Breeds at Rattlesnake Springs commonly each year; also possible in adjacent dry canyons.
	Black-chinned Sparrow	Extensive	Breeds at higher elevations (Yucca Mesa, Open Hollow Gulch) and, to a lesser degree, in lower canyons.
	Common Black-Hawk	Limited	Mostly a spring and fall migrant; requires undisturbed riparian habitat for breeding.
	Gray Vireo	Extensive	Common in dry canyons and slopes throughout the park.
	Scaled Quail	Extensive	Common throughout park at riparian areas (Rattlesnake Springs) and upland sites.
	Varied Bunting	Moderate	Found regularly at many sites (e.g., Rattlesnake, Slaughter, and Walnut canyons) and less regularly at Rattlesnake Springs.

* Limited = Small area(s) of breeding habitat exist in the park. Moderate = Substantial breeding habitat exists in the park. Extensive = Breeding habitat is common to abundant in the park. Possible = Breeding habitat is marginal in quality and/or its presence is uncertain.

Table 3-2, cont. Habitat availability classes assigned to each species of conservation concern at CHDN parks. Information is shown only for species/parks designated with "+" in Table 3-1 (i.e., those species known to breed in the park).

Parks where Breed	Species	Habitat Availability*	Notes
cont... Carlsbad Caverns NP	Willow Flycatcher	Limited	As many as three pairs have bred at Rattlesnake Springs in the past, the only nesting pairs in the Pecos Valley.
	Yellow-billed Cuckoo	Moderate	Common nesting species at Rattlesnake Springs; less common in adjacent dry canyons (Walnut Canyon, Slaughter Canyon, etc.) as a nesting species.
Fort Davis NHS	Black-chinned Sparrow	Moderate	Breeds on grass & catclaw-covered slopes in Hospital Canyon and Limpia Canyon; winters in mixed flocks within that same habitat.
	Scaled Quail	Moderate	Possibly breeds on occasion within Hospital Canyon and mesquite grasslands north of park entrance.
Guadalupe Mountains NP	Band-tailed Pigeon	Extensive	Breeds in montane woodlands above 7,000 ft. Much less common than 40 yrs ago; reason for decline is unknown.
	Black-chinned Sparrow	Moderate	Breeds on grass-covered slopes, especially in presence of catclaw and/or shrubby vegetation; throughout the park.
	Flammulated Owl	Moderate	Breeds in montane woodlands above 7,500 ft; fairly common in well-developed woodlands.
	Grace's Warbler	Extensive	Common to abundant breeding species in montane woodlands.
	Gray Vireo	Limited	Habitat specialist that breeds in early successional growth, woody vegetation in foothill canyons, transition between grassland alluvial fans, and mature riparian woodlands like that found in the lower sections of McKittrick Canyon.
	Mexican Spotted Owl	Limited	Habitat specialist that breeds in secluded deep-cut canyons with a well-developed woodland component; as a result, breeding pairs limited within the park.
	Mexican Whip-poor-will	Extensive	Common breeding species in montane woodlands.
	Olive-sided Flycatcher	Moderate	Southernmost breeding population in the Rocky Mountains chain; uncommon breeding species in montane woodlands.
	Peregrine Falcon	Limited	Cliff-nesting species that is limited by available nesting sites.
	Scaled Quail	Extensive	Common to abundant nesting species in the foothills of the mountains and surrounding desert flats.
	Virginia's Warbler	Extensive	Uncommon nesting species in montane woodlands and riparian zones.
	Yellow-billed Cuckoo	Limited	Limited by lack of breeding habitat; breeds in riparian areas with mature cottonwood/willow woodlands (such as that found at Rattlesnake Springs just northeast of the park).
White Sands NP	Scaled Quail	Extensive	Species observervations are common in the parabolic dunes.
	Snowy Plover	Possible	Have been seen at Lake Lucero in wet years; not common in the park. Very common nearby at Lake Holloman.

* Limited = Small area(s) of breeding habitat exist in the park. Moderate = Substantial breeding habitat exists in the park. Extensive = Breeding habitat is common to abundant in the park. Possible = Breeding habitat is marginal in quality and/or its presence is uncertain.

Table 3-3. Summary table of species of conservation concern by species that are known to breed in a given park, and whether the park has moderate or extensive breeding habitat availability for the species. Note that parks/species with limited habitat are not included here.

Species	Parks with Moderate Habitat Availability	Parks with Extensive Habitat Availability
Band-tailed Pigeon	—	GUMO
Black-capped Vireo	BIBE	—
Black-chinned Sparrow	BIBE, FODA, GUMO	CAVE
Flammulated Owl	GUMO	—
Grace's Warbler	—	GUMO
Gray Vireo	—	CAVE
Least Tern	—	AMIS
Lucifer Hummingbird	BIBE	—
Mexican Whip-poor-will	—	GUMO
Olive-sided Flycatcher	GUMO	—
Scaled Quail	FODA	AMIS, BIBE, CAVE, GUMO, WHSA
Snowy Plover	AMIS	—
Varied Bunting	CAVE	—
Virginia's Warbler	—	GUMO
Yellow-billed Cuckoo	CAVE	—

Park acronyms: AMIS = Amistad NRA, BIBE = Big Bend NP, CAVE = Carlsbad Caverns NP, FODA = Fort Davis NHS, GUMO = Guadalupe Mountains NP, WHSA = White Sand NP.

3.2 Species Richness and Composition

3.2.1 Chihuahuan Desert Network Parks: Overall Estimates

3.2.1.1 Species Richness and Composition

The coefficient of variation revealed that using only breeding species well-surveyed by point counts had the least variability in first-order jackknife estimates. These first-order jackknife estimates for the CHDN parks were standardized using the mean and standard deviation across years for each park-habitat to illustrate the relative spread and variation for each park (Figure 3-2). The average range of raw species richness across parks was 11.3 species. Guadalupe Mountains NP Upland, Amistad NRA Upland, and Carlsbad Caverns NP Riparian had the largest ranges in jackknife estimates and in raw richness (Table 3-4). Across all parks, the lowest species richness estimated (24.6) was in Carlsbad Caverns NP riparian habitat in 2010. The largest species richness estimate (61.9) was in Amistad NRA riparian habitat in 2013.

3.2.1.2 Breeding Habitat Guilds

In our analysis of breeding habitat guilds, we found that in park upland habitats, the shrubland breeding habitat guild comprised the largest average proportion of species (36.0%; Figure 3-3). The upland generalist guild was second largest (26.0%), while the grassland/savanna guild comprised one of the smallest average proportions of species (11.1%). Breeding species found in park riparian habitats were 27.1% woodland species and 23.9% upland generalist species, when the proportion of species in each breeding habitat guild was averaged over years and parks (Figure 3-3). We com-

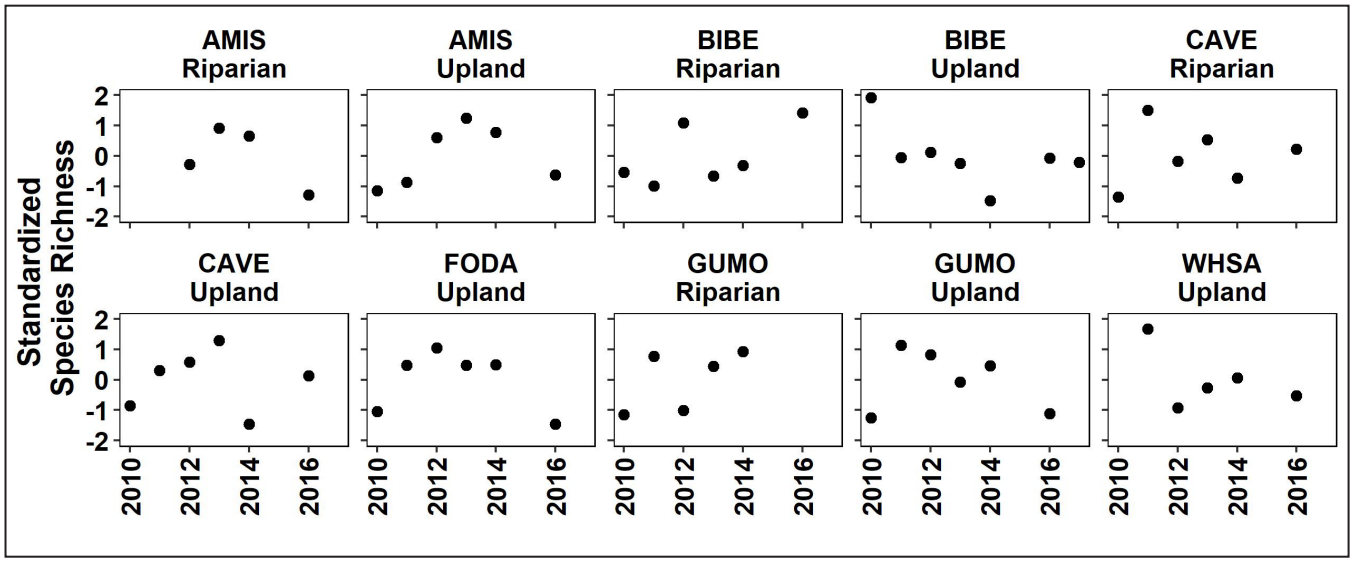


Figure 3-2. Species richness first-order jackknife estimates for breeding species well-surveyed by point counts. Estimates are standardized using the mean and standard deviation across years in each surveyed park and habitat type. [Park acronyms: AMIS = Amistad NRA, BIBE = Big Bend NP, CAVE = Carlsbad Caverns NP, FODA = Fort Davis NHS, GUMO = Guadalupe Mountains NP, WHSA = White Sands NP].

Table 3-4. Minimum, maximum, and range of raw and estimated species richness for each park and habitat combination (with the relevant year in parentheses). Results are based only on breeding species well-surveyed by point counts.

Unit Habitat	Raw Minimum (and Year)	Raw Maximum (and Year)	Estimate Minimum (and Year)	Estimate Maximum (and Year)	Raw Range	Estimate Range
AMIS Riparian	40 (2016)	52 (2013, 2014)	46.2 (2016)	61.9 (2013)	12	15.7
AMIS Upland	32 (2010)	48 (2013)	38.1 (2010)	56.9 (2013)	16	18.8
BIBE Riparian	35 (2010)	39 (2012, 2014)	43.2 (2011)	50.8 (2016)	4	7.6
BIBE Upland	28 (2014)	40 (2010)	30.9 (2014)	49.5 (2010)	12	18.7
CAVE Riparian	22 (2010)	36 (2011)	24.6 (2010)	46.5 (2011)	14	21.9
CAVE Upland	26 (2014)	37 (2013)	31.3 (2014)	47.5 (2013)	11	16.3
FODA Upland	27 (2016)	38 (2012)	31.7 (2016)	44.7 (2012)	11	13.0
GUMO Riparian	29 (2012)	38 (2011, 2014)	33.8 (2010)	46.4 (2014)	9	12.7
GUMO Upland	26 (2010)	43 (2011)	33.9 (2010)	56.3 (2011)	17	22.5
WHSA Upland	21 (2012)	28 (2011)	27.3 (2012)	35.2 (2011)	7	7.9

Park acronyms: AMIS = Amistad NRA, BIBE = Big Bend NP, CAVE = Carlsbad Caverns NP, FODA = Fort Davis NHS, GUMO = Guadalupe Mountains NP, WHSA = White Sand NP.

pared breeding habitat guild proportions among parks and habitats surveyed, and found that:

- White Sands NP Upland had the largest average proportion of grassland/savanna breeding habitat species (24.3%).
- Guadalupe Mountains NP Riparian had the largest proportion of woodland breeding habitat species (54.6%).
- Carlsbad Caverns NP Riparian had the largest proportion of riparian/wetland breeding habitat species (34.0%).

- Big Bend NP Upland had the largest proportion of shrubland breeding habitat species (44.8%).
- Carlsbad Caverns NP Upland had the largest proportion of upland generalist breeding habitat species (30.6%).

3.2.2 Park-specific Estimates

3.2.2.1 Amistad NRA

Amistad NRA Riparian

In Amistad NRA riparian habitat surveyed, the grassland/savanna breeding habitat guild comprised the lowest proportion of species, 7.8%, when averaged across years (Figure 3-4). The riparian/wetland guild comprised the highest proportion of species (26.5%), and the upland generalist guild comprised the second highest proportion of species (25.7%). Raw and estimated species richness for Amistad NRA Riparian are shown for each year surveyed in Figure 3-5. The lowest species richness, for both the raw and the estimate (46.2), was in 2016. The highest species richness estimate was 61.9 species in 2013. The highest raw species richness was in 2013 and 2014. The richness range between highest and lowest years was 12 for raw observations and 15.7 for first-order jackknife estimates (see Table 3-4).

Amistad NRA Upland

In Amistad NRA upland habitat surveyed, the grassland/savanna breeding habitat guild comprised the lowest proportion of species (9.9%) when averaged across years (Figure 3-4). The shrubland guild comprised the highest proportion of species, at 26.8%,

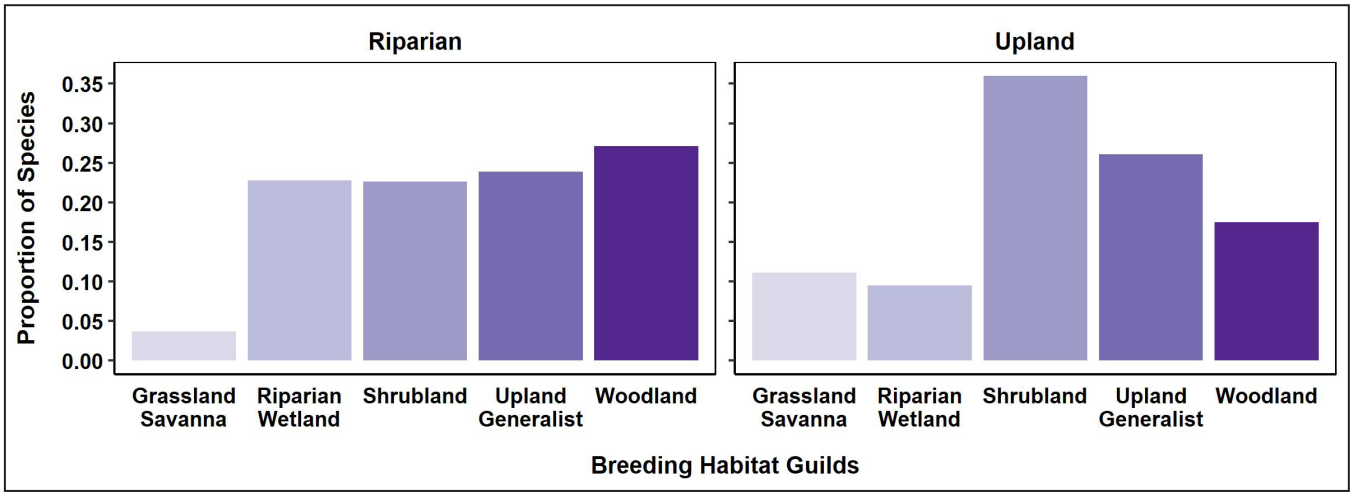


Figure 3-3. The proportion of species in each breeding habitat guild for surveyed riparian and upland habitats averaged across parks and years in the CHDN.

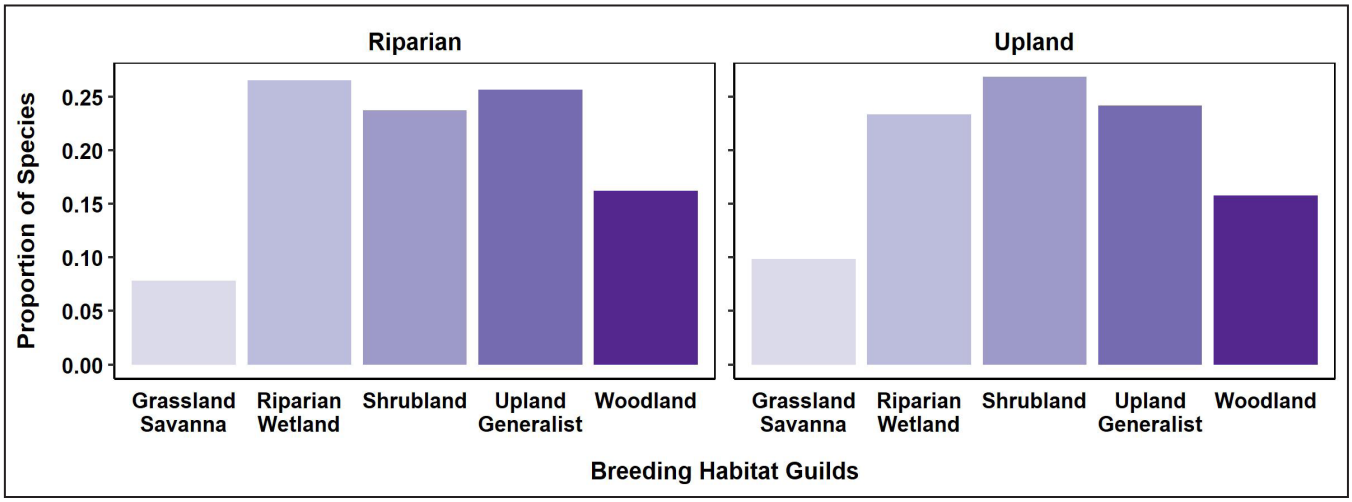


Figure 3-4. The proportion of species in each breeding habitat guild for surveyed riparian and upland habitats in Amistad NRA averaged over years.

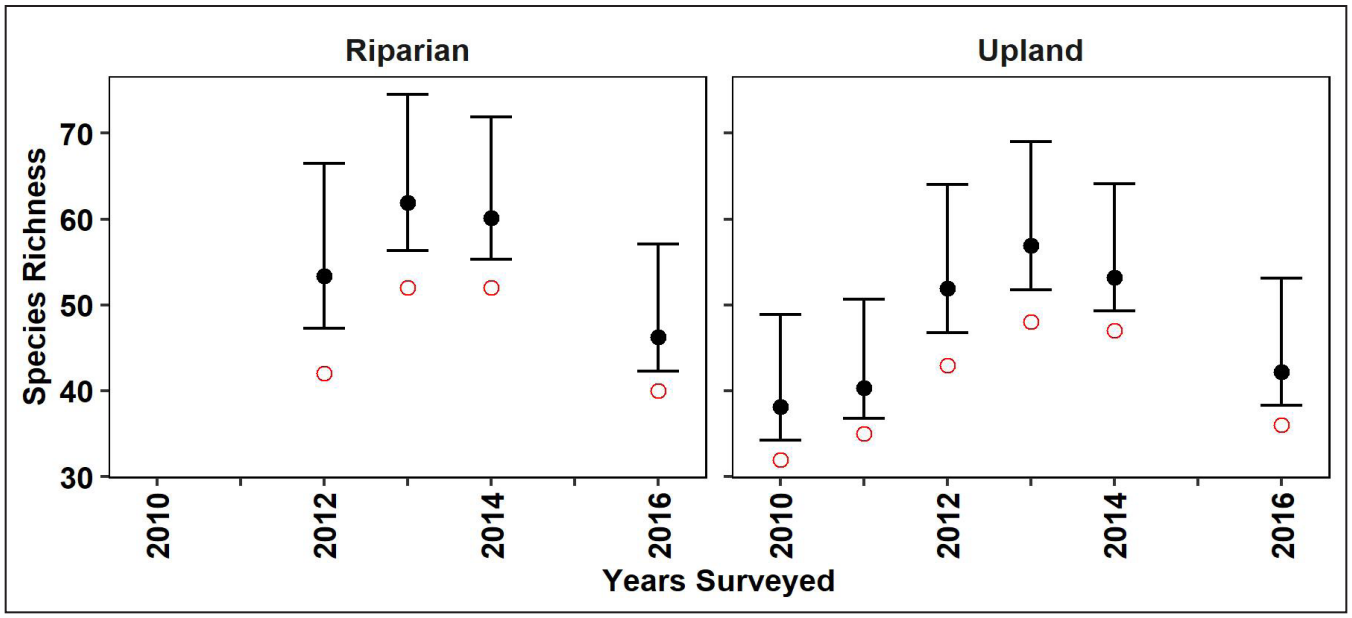


Figure 3-5. Amistad NRA species richness raw (open, red circle) and first-order jackknife (black with 95% CL) estimates for years of riparian and upland habitats surveyed. Analysis used breeding species well-surveyed by point counts.

and the upland generalist guild comprised the second highest proportion of species, at 24.2%. Raw and estimated species richness for Amistad NRA Upland are shown for each year surveyed in Figure 3-5. The highest species richness, for both the raw and the estimate (56.9), was in 2013. The lowest species richness estimate (38.1) and raw count was in 2010. The richness range from highest to lowest year was 16 for raw observations and 18.8 for first-order jackknife estimates (see Table 3-4).

3.2.2.2 Big Bend NP

Big Bend NP Riparian

In Big Bend NP riparian habitat surveyed, the grassland/savanna breeding habitat guild comprised the lowest proportion of species (1.4%) when averaged across years (Figure 3-6). The shrubland guild comprised the highest proportion of species (36.1%), and the riparian/wetland guild comprised the second highest proportion of species (24.6%). Raw and estimated species richness for Big Bend NP Riparian are shown for each year surveyed in Figure 3-7. The lowest raw species richness was in 2010, and that for the estimate was in 2011 (43.2). The highest species richness estimate was 50.8 species in 2016. The highest raw species richness was in 2012 and 2014. The richness range, from highest to lowest year, was 4 using the raw observations and 7.6 using the first-order jackknife estimates (see Table 3-4).

Big Bend NP Upland

In Big Bend NP upland habitat surveyed, the grassland/savanna breeding habitat guild comprised the lowest proportion of species (5.5%) when averaged across years (Figure 3-6). The shrubland guild comprised the highest proportion of species (44.8%), and the upland generalist guild comprised the second highest proportion (24.0%). Raw and estimated species richness for Big Bend NP Upland are shown for each year surveyed in Figure 3-7. The highest species richness, for both the raw and the estimate (49.5), was in 2010. The lowest species richness estimate (30.9) and raw count was in 2014. The richness range, from highest year to lowest year, was 12 using the raw observations and 18.7 using the first-order jackknife estimates (see Table 3-4).

3.2.2.3 Carlsbad Caverns NP

Carlsbad Caverns NP Riparian

In the Carlsbad Caverns NP riparian habitat surveyed, the grassland/savanna breeding habitat guild comprised the lowest proportion of species (4.2%) when averaged across years (Figure 3-8). The riparian/wetland guild comprised the highest proportion of species (at 34.0%), and the upland generalist

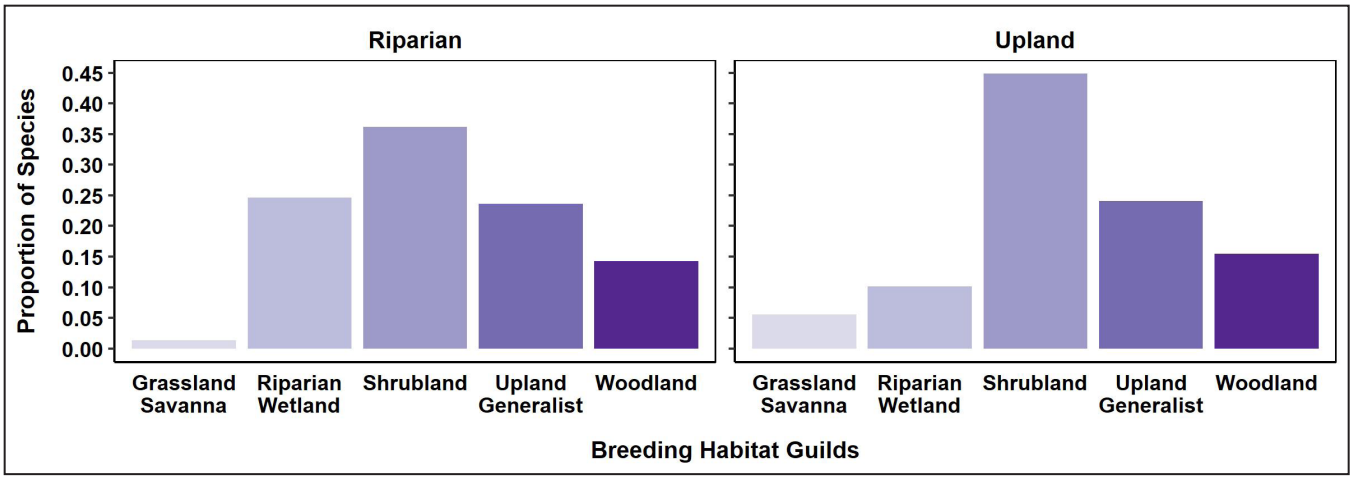


Figure 3-6. The proportion of species in each breeding habitat guild for surveyed riparian and upland habitats in Big Bend NP averaged over years.

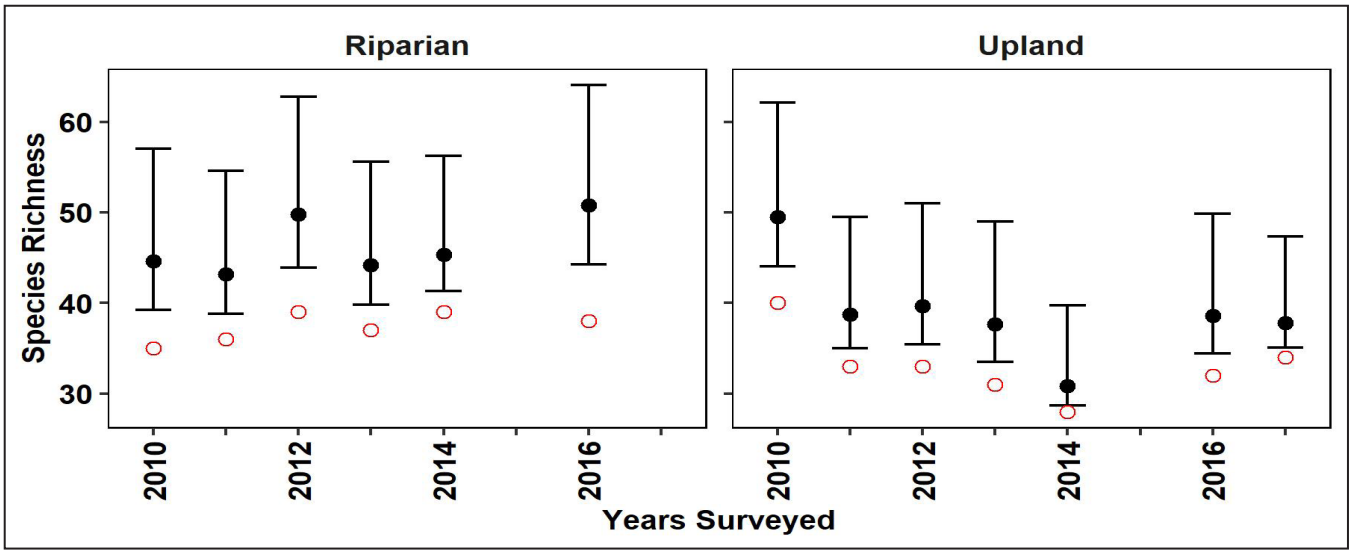


Figure 3-7. Big Bend NP species richness raw (open, red circle) and first-order jackknife (black with 95% CL) estimates for years of riparian and upland habitats surveyed. Analysis used breeding species well-surveyed by point counts.

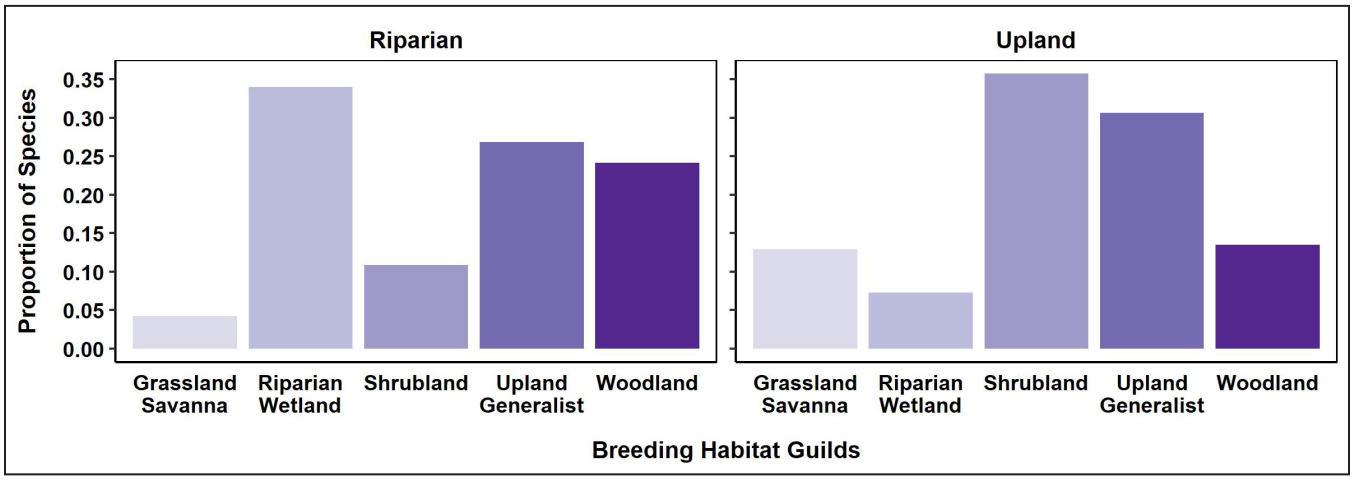


Figure 3-8. The proportion of species in each breeding habitat guild for surveyed riparian and upland habitats in Carlsbad Caverns NP averaged over years.

guild comprised the second highest proportion of species (26.8%). Raw and estimated species richness for Carlsbad Caverns NP Riparian are shown for each year surveyed in Figure 3-9. The lowest species richness, for both the raw and the estimate (24.6), was in 2010. The highest species richness estimate (46.5) and raw count was in 2011. The richness range, from highest to lowest year, was 14 for raw observations and 21.9 for first-order jackknife estimates (see Table 3-4).

Carlsbad Caverns NP Upland

In Carlsbad Caverns NP upland habitat surveyed, the riparian/wetland breeding habitat guild comprised the lowest proportion of species (7.3%), the shrubland guild comprised the highest proportion of species (35.7%), and the upland generalist guild comprised the second highest proportion of species (30.6%), when averaged across years (Figure 3-8). Raw and estimated species richness for Carlsbad Caverns NP Upland are shown for each year surveyed in Figure 3-9. The highest species richness, for both the raw and the estimate (47.5), was in 2013. The lowest species richness estimate (31.3) and raw count was in 2014. The richness range, from highest to lowest year, was 11 for raw observations and 16.3 for first-order jackknife estimates (see Table 3-4).

3.2.2.4 Fort Davis NHS

Fort Davis NHS Upland

In Fort Davis NHS upland habitat surveyed, the riparian/wetland breeding habitat guild comprised the lowest proportion of species (7.9%) when averaged across years (Figure 3-10 [A]). The shrubland guild comprised the highest proportion of species (33.0%), and the upland generalist guild comprised the second highest proportion of species (28.6%). Raw and estimated species richness for Fort Davis NHS Upland are shown for each year surveyed in Figure 3-10 [B]. The highest species richness, for both the raw and the estimate (44.7), was in 2012. The lowest species richness estimate (31.7) and raw count was in 2016. The richness range, from highest to lowest year, was 11 for raw observations and 13.0 for first-order jackknife estimates (see Table 3-4).

3.2.2.5 Guadalupe Mountains NP

Guadalupe Mountains NP Riparian

In Guadalupe Mountains NP riparian habitat surveyed, the grassland/savanna breeding habitat guild comprised the lowest proportion of species (2.4%) when averaged across years (Figure 3-11). The woodland guild comprised the highest proportion of species (54.6%), and the shrubland guild comprised the second highest proportion of species (19.6%), followed closely by the upland generalist guild (19.4%). Raw and estimated species richness for Guadalupe Mountains NP Riparian are shown for each year surveyed in Figure 3-12. The lowest species richness estimate was 33.8 species in 2010, and the lowest raw species richness was in 2012. The highest

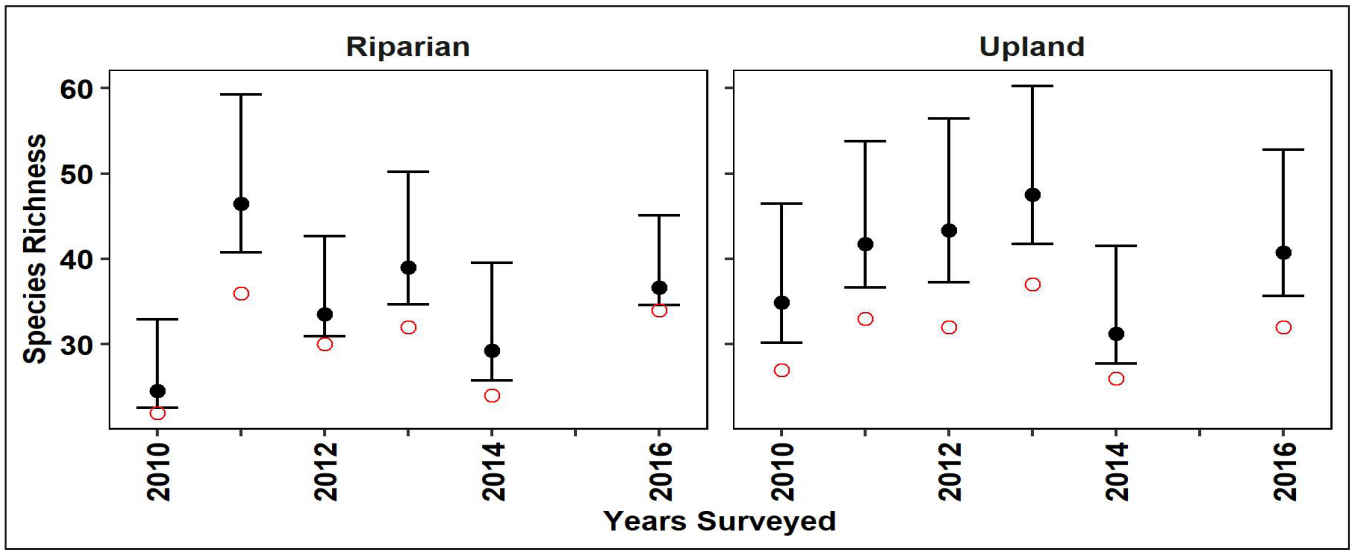


Figure 3-9. Carlsbad Caverns NP species richness raw (open, red circle) and first-order jackknife (black with 95% CL) estimates for years of riparian and upland habitats surveyed. Analysis used breeding species well-surveyed by point counts.

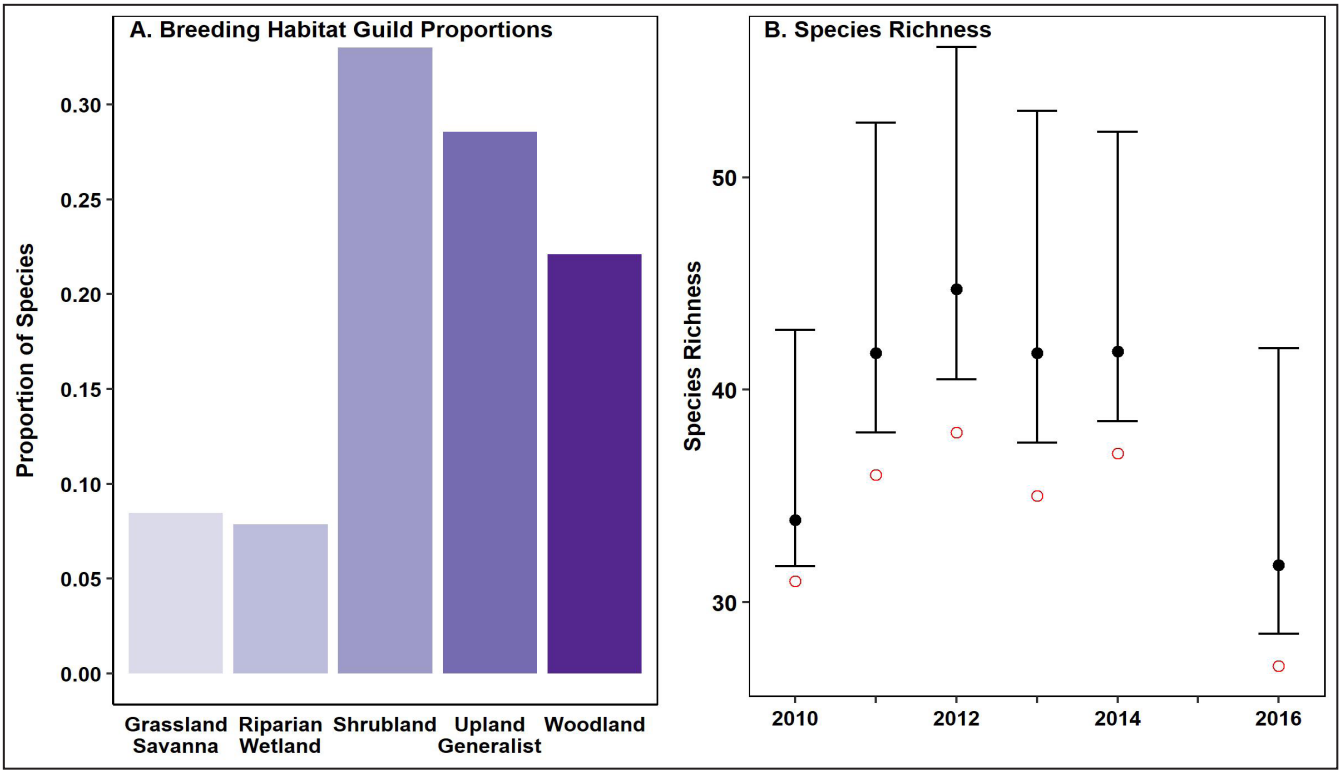


Figure 3-10. The proportion of species in each breeding habitat guild for surveyed upland habitat in Fort Davis NHS averaged over years (a); and Fort Davis NHS species richness raw (open, red circle) and first-order jackknife (black with 95% CL) estimates in upland habitat for years surveyed (b). Analysis used breeding species well-surveyed by point counts.

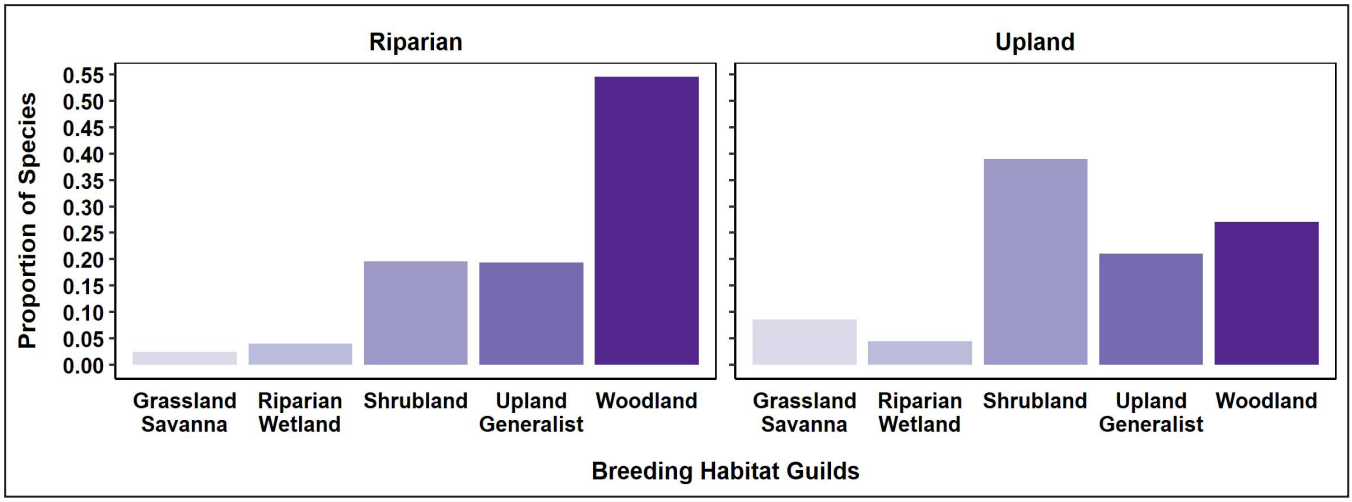


Figure 3-11. The proportion of species in each breeding habitat guild for surveyed riparian and upland habitats in Guadalupe Mountains NP averaged over years.

species richness estimate was 46.4 species in 2014. The highest raw species richness was in 2011 and 2014. The richness range, from highest to lowest year, was 9 for raw observations and 12.7 for first-order jackknife estimates (see Table 3-4).

Guadalupe Mountains NP Upland

In Guadalupe Mountains NP upland habitat surveyed, the riparian/wetland breeding habitat guild comprised the lowest proportion of species (4.4%) when averaged across years (Figure 3-11). The shrubland breeding habitat guild comprised the highest proportion of species (39.0%), and the woodland guild comprised the second highest proportion of species (27.0%). Raw and estimated species richness for Guadalupe Mountains

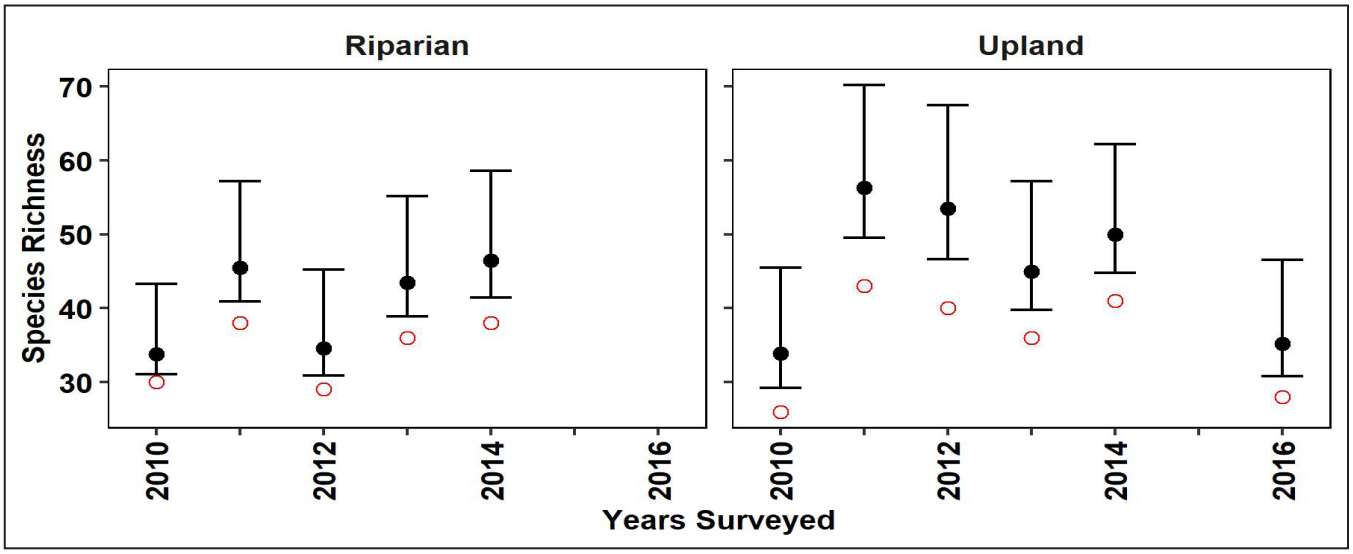


Figure 3-12. Guadalupe Mountains NP species richness raw (open, red circle) and first-order jackknife (black with 95% CL) estimates for years of riparian and upland habitats surveyed. Analysis used breeding species well-surveyed by point counts.

NP Upland are shown for each year surveyed in Figure 3-12. The highest species richness, for both the raw and the estimate (56.3), was in 2011. The lowest species richness estimate (33.9) and raw count was in 2010. The richness range, from highest to lowest year, was 17 using the raw observations and 22.5 using the first-order jackknife estimates (see Table 3-4).

3.2.2.6 White Sands NP

White Sands NP Upland

In White Sands NP upland habitat surveyed, the riparian/wetland breeding habitat guild comprised the lowest proportion of species (2.5%) when averaged across years (Figure 3-13 [A]). The shrubland guild comprised the highest proportion of species (34.7%), and the upland generalist guild comprised the second highest proportion of species (28.6%). Across all parks and habitats, White Sands NP had the largest proportion of grassland species—24.3%. Raw and estimated species richness for White Sands NP Upland are shown for each year surveyed in Figure 3-13 [B]. The highest species richness, for both the raw and the estimate (35.2), was in 2011. The lowest species richness estimate (27.3) and raw count was in 2012. The richness range, from highest to lowest year, was 7 using the raw observations and 7.9 using the first-order jackknife estimates (see Table 3-4).

3.2.3 Species Richness and Composition Discussion

For each surveyed park upland, the shrubland breeding habitat guild comprised the largest proportion of species. The grassland guild comprised the lowest proportion of species in Amistad NRA and Big Bend NP uplands. In surveyed uplands at Carlsbad Caverns NP, Fort Davis NHS, and Guadalupe Mountains NP, the riparian/wetland guild comprised the lowest proportion of species, and the grassland/savanna guild comprised the second lowest. These results provide evidence that each park in the CHDN supports more shrubland species than grassland species.

A complicated past in the Chihuahuan Desert, with different fire regimes, unsustainable grazing intensities, direct human alteration of plant communities, and fire suppression, has resulted in changes in vegetation composition and structure and fuel loads (Nadeau et al. 2014, Nadeau et al. 2017, Valentine-Darby et al. 2016). Since European settlement in the mid to late 1800s, Chihuahuan Desert grasslands have been encroached by shrubs and small trees, such as juniper (*Juniperus* spp.), creosote bush (*Larrea tridentata*), mesquite (*Prosopis glandulosa*), and tarbush (*Flourensia cernua*) (Nadeau et al. 2014, Nadeau et al. 2017, White et al. 2008). It is not surprising that under these conditions, in park uplands, the shrubland guild has greater richness than the grassland guild.

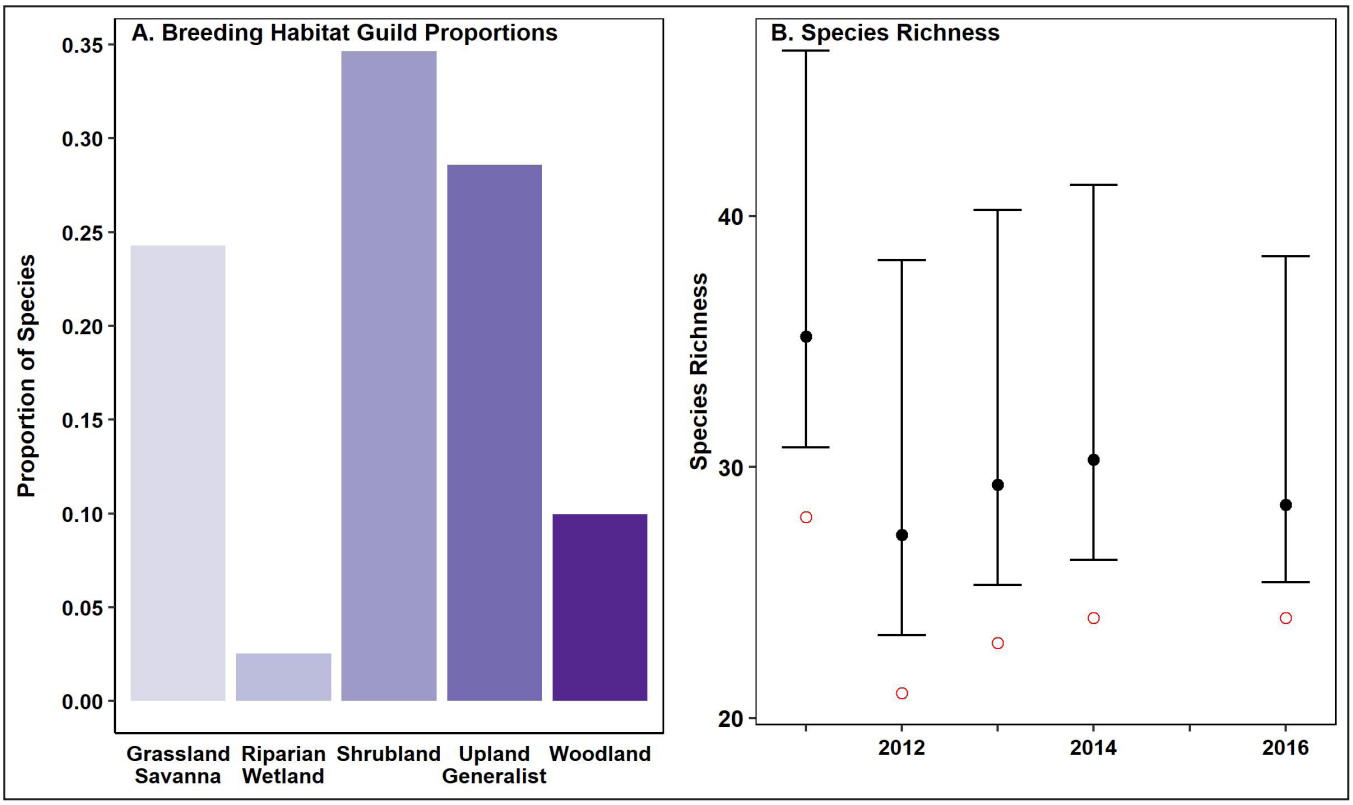


Figure 3-13. The proportion of species in each breeding habitat guild for surveyed upland habitat in White Sands NP averaged over years (a); and White Sands NP species richness raw (open, red circle) and first-order jackknife (black with 95% CL) estimates in upland habitat for years surveyed (b). Analysis used breeding species well-surveyed by point counts.

Future concerns for park uplands include deviations from a natural fire regime, human disturbance, ability to recover from past grazing, encroachment of native shrubs, and invasive species introduction and expansion (Benck et al. 2017, Kilkus et al. 2013, Nadeau et al. 2014, Nadeau et al. 2017, Valentine-Darby et al. 2016). All of these issues are expected to be exacerbated by climate change. The eastern Chihuahuan Desert may experience slight increases in precipitation, although models have high uncertainty (Archer and Predick 2008). The western Chihuahuan Desert is expected to experience drier conditions, with aridity increasing westward (Archer and Predick 2008). Climate change is expected to produce hotter conditions, with more frequent extremely high temperatures, fewer frost days, declines in snow pack, and an earlier spring melt (Archer and Predick 2008). All of these conditions combined create a longer dry season and more drought; this will decrease plant productivity and is expected to increase intensity and frequency of wildfires (Archer and Predick 2008, Munson et al. 2013). The dry, warmer conditions are expected to favor drought-tolerant species (Munson et al. 2013), but exact plant community composition changes are uncertain (Archer and Predick 2008). Local plant species assemblages and responses of individual species to the changes will ultimately determine the landscape-level changes; these changes will in turn influence fauna (Friggens et al. 2012, Munson et al. 2013). Future changes to the parks will likely impact suitability for grassland breeding specialists.

The breeding bird habitat guild that comprised the largest proportion of species was more variable between parks in surveyed riparian habitat than between parks in surveyed upland habitat. Woodland, riparian/wetland, and shrubland breeding habitat guilds were the most species-rich guilds in surveyed riparian areas. In addition, estimated Amistad NRA and Big Bend NP riparian species richness was higher each year than in surveyed upland habitat (with the exception of Big Bend NP 2010, but surveys occurred much later that year). This demonstrates

the importance of riparian areas for species composition in parks and for contributing to greater richness overall. The mixed guild dominance is likely driven by the varied riparian habitats present in the parks. Amistad NRA watersheds include plains, plateau, mountains, reservoir, springs, and basins, and vary naturally and due to human influence (Valentine-Darby et al. 2016). Amistad NRA plants in riparian areas include woody and herbaceous riparian wetland species (Valentine-Darby et al. 2016). Big Bend NP has heterogeneous plant communities ranging from emergent wetland to cottonwood (*Populus*) stands, and diverse physiognomies from narrow canyons to widespread floodplains (Nadeau et al. 2014). Big Bend NP also has springs whose flows can vary widely between years (and across seasons) due to different precipitation levels (Nadeau et al. 2014). Guadalupe Mountains NP riparian areas are composed of one perennial stream and many semipermanent springs that support rare and endemic plant species and are composed of hardwood woodlands, commonly with grass and other herbaceous understories (Kilkus et al. 2013). Carlsbad Caverns NP riparian areas consist of springs and seeps that support herbaceous wetlands and forested wetlands; forested wetlands include Rio Grande cottonwood (*Populus deltoides* ssp. *wislizenii*) and Oak-Madrone band cove woodlands (Benck et al. 2017). This diversity both within and between park riparian areas increases species richness and composition complexity. It is also important to recognize that riparian point counts include birds associated with upland habitats (such as desert shrub, pinyon-juniper, and ponderosa woodlands), and upland point counts near riparian areas include riparian specialists, due to close proximity of habitats. This contributes to the complexity of breeding habitat guilds and species richness that we report.

These diverse riparian areas are important for breeders as well as migrants, but climate change will likely cause deterioration of CHDN riparian areas (Archer and Predick 2008). Some issues expected are lower peak discharge magnitude, increased temperatures, reduced frequency of rainfall, more frequent and intense drought, increased intensity of rainfall events that do occur and associated floods, fewer cottonwoods (important nesting habitat), and increases in non-natives, such as saltcedar (*Tamarix ramosissima*, also known as tamarisk), giant cane (*Arundo donax*), and Bermuda grass (*Cynodon dactylon*; Archer and Predick 2008, Kilkus et al. 2013, Nadeau et al. 2014, Smith and Finch 2017, Struthers et al. 2014, Valentine-Darby et al. 2016). This deterioration can be expected to negatively impact birds that breed, feed, and migrate in these riparian areas.

Regardless of habitat, climate change is expected to impact species richness and composition in CHDN parks (Wu et al. 2018). Across Europe, the number and proportion of long-distance migrant species decreased as winter temperature increased, and the number and proportion of resident species increased as the coldest month increased in temperature (Lemoine and Böhning-Gaese 2003). The Chihuahuan Desert is expected to have fewer frost days, and therefore can also expect changes in species composition (Archer and Predick 2008). Researchers predict generalists to be favored over specialists due to expected loss of specialized breeding habitat and replacement with non-natives, as well as the impact of climate suitability on success of colonization (La Sorte 2006, Menéndez et al. 2006, and Rosenzweig et al. 2007). Ultimately, maintenance or changes in species richness depend on the ability of birds to colonize and shift ranges, as well as to adapt to abiotic changes resulting in different plant communities (La Sorte 2006, Menéndez et al. 2006, Rosenzweig et al. 2007). Overall, the ability to address future concerns related to land use and management in parks will play an important role in resilience of systems, as climate change is anticipated to exacerbate these issues.

3.3 Estimates of Species Occupancy and Density

3.3.1 Species Accounts

3.3.1.1 Introduction

In this section of the report, we present species accounts for all breeding species that we considered adequately surveyed by the methods used (i.e., excluding colonial, nocturnal,

and low-breeding-density birds), and for which sufficient data were available for the analyses. We do not present species accounts for species with occupancy estimates in only one park-habitat; however, we provide a table and some discussion of these species in Section 3.3.1.53 of this chapter (after the last species account).

The species accounts present occupancy and density results (in separate tables) for each species by park-habitat (e.g., Amistad NRA Upland). We also present conservation status information for each species in a third table. As an introduction to the species accounts, we provide a brief discussion of each of the results tables below.

In the occupancy table we present occupancy results for both transect (Psi) and point (Theta), as appropriate. For park-habitats with multiple transects, we estimated transect occupancy and conditional point occupancy, where point occupancy applies only to occupied transects. Note that in the species accounts, we do not discuss point occupancy for these park-habitats. For park-habitats with a single transect (Fort Davis NHS Upland and Carlsbad Caverns NP and Guadalupe Mountains NP Riparian), we did not estimate transect-level occupancy; we instead estimated unconditional point-level occupancy, where point occupancy estimates are not dependent on transects.

Estimated occupancy is averaged across years, and each estimate is shown with the 95% credible interval (CI; defined as there being an estimated 95% probability that the true occupancy probability is within the credible interval, conditional on model assumptions and assumed prior distributions). We also provide the coefficient of variation (CV) for the estimate, and n (the number of "species detections," where a detection is a 2-minute time interval during a point-visit with at least one individual detected). Finally, we include the rank position of a species' occupancy relative to other species' occupancy estimates for the same park-habitat combination, with "1" indicating highest occupancy. We report average transect occupancy for estimates with a CV of 50% or less. For average point occupancy, we limited CVs to 50% or less only for park-habitats with single transects (Fort Davis NHS Upland and Carlsbad Caverns NP and Guadalupe Mountains NP Riparian). As described in the methods chapter, for each park-habitat combination we report results only for species with 10 or more point detections combined across years for that park and habitat.

To present occupancy results (for both transect and point occupancy) in the species accounts text, we categorize each estimate (i.e., median of posterior distribution) as "low," "moderate," or "high." Occupancy estimates from 0 to 0.33 are "low," estimates from 0.34 to 0.66 are "moderate," and estimates from 0.67 to 1.0 are "high." Note, however, that we categorize estimates only when the credible interval range is ≤0.05.

We provide density estimates (averaged across years) in number of birds per hectare (ha [1 ha = 2.47 acres]), along with lower and upper confidence limits (LCL, UCL). We also provide the CV for the estimate, as well as the number of individuals detected per park-habitat (n). Finally we provide rank, which is the species' position in a park-habitat list with "1" being the species with the greatest estimated density. To qualify for analysis, a species had to have at least 100 detections combined across years for each park and habitat combination.

As just described, the occupancy and density estimates presented in this chapter are averaged across years. We also present occupancy and density estimates *by year* in Appendix D and Appendix E, respectively.

In the conservation status table, we present 12 different scores/rankings for the species at global, continental, federal, regional, and state scales. We used five of these rankings in the species of conservation concern section of the report (i.e., Section 3.1)— NatureServe Global (G) rank, federal listing under the Endangered Species Act, state listing by Texas and/or New Mexico, and Level 1 species with the New Mexico Avian Conservation Partners (NMACP). These five rankings were discussed and defined (with their sources) in Chapter 2 (Section 2.4.1). The only exception to this is that for the species

accounts (compared to the SCC section) we report the G rank for species that are less vulnerable (and therefore have higher G ranks not defined in Section 2.4.1). This higher G rank, G5, is defined as "Secure—at very low risk of extinction or elimination due to a very extensive range, abundant populations or occurrences, and little to no concern from declines or threats" (NatureServe 2020). Nearly every species in the species accounts has a G5 rank; only one species (Loggerhead Shrike) has a more vulnerable global ranking (G4). Although they are shown in the table, we do not specifically discuss G rankings in the species accounts.

The other seven rankings that we used for the species accounts are primarily regional rankings; they are:

- Continental Combined Score (max)
- Regional Population Trend (PT-r)
- Regional Threats-Breeding (TB-r)
- Relative Density-Breeding (RD-b)
- Percent of Global Population in Bird Conservation Region (% Pop)
- Regional Concern
- Regional Stewardship

The source for these rankings was the Avian Conservation Assessment Database (ACAD; Partners in Flight 2019, 2020). The rankings are described in significant detail in Panjabi et al. (2020), which is the source for all of the descriptions that follow. A Partners in Flight (PIF) ranking was also used in Section 2.4.1, but for the SCC we used a different ranking (i.e., Continental Watch List species) than we used here.

The first ranking, the Continental Combined Score (max) (CCS-max) is the highest of either the CCS for the breeding season (CCS-b) or the CCS for the non-breeding season (CCS-n). The CCS-b and the CCS-n are themselves made up of four component scores each, dealing with population size, distribution, threats, and population trend. Each of the four component scores range from 1 to 5, with a 1 representing low vulnerability and a 5 representing high vulnerability. Continental Combined Scores range from 4 (low vulnerability) to 20 (high vulnerability). In presenting the CCSs in the text, we categorize the score as "low" when it is 4 to 8, "moderate" when it is 9 to 15, and "high" when it is 16 to 20.

As noted, the other six rankings are at the regional level. An important component of the regional rankings used by PIF is the Bird Conservation Region (BCR). Bird Conservation Regions are "ecologically distinct regions in North America with similar bird communities, habitats, and resource management issues" (Bird Studies Canada and North American Bird Conservation Initiative [NABCI] 2014). These regions consist of areas that are similar in their abiotic and biotic characteristics, and they may be split into smaller units or combined when a finer or larger scale, respectively, is desired for conservation planning/action (Bird Studies Canada and NABCI 2014). Five of the six CHDN parks are entirely within BCR 35 (named Chihuahuan Desert; Figure 3-14). Amistad NRA falls within BCR 35 and BCR 36 (Tamaulipan Brushland). Note that regional information in the species accounts is for BCR 35 only, but we present information on BCR 36 for birds in Amistad NRA in Appendix F.

The Regional Population Trend (PT-r) is an indication of vulnerability due to the direction (increasing or decreasing) and magnitude of recent changes in population size within the region. Scores for this ranking range from 1 (significant large increase) to 5 (significant large decrease).

Regional Threats to Breeding (TB-r) assesses, on a regional level, vulnerability to the effects of current and likely future conditions that threaten the population's ability to persist and reproduce successfully during the breeding season. Scores range from 1 (low vulnerability) to 5 (high vulnerability).

The Relative Density-Breeding (RD-b) score is an indication of the mean density of a species within a BCR, relative to the density in the BCR(s) with the highest density(ies). It is not affected by the size of the BCR or absolute abundance of the species. Table 3-5 describes the possible scores, from 0 to 5. Panjabi et al. (2020) states that "the underlying assumption of this score is that conservation

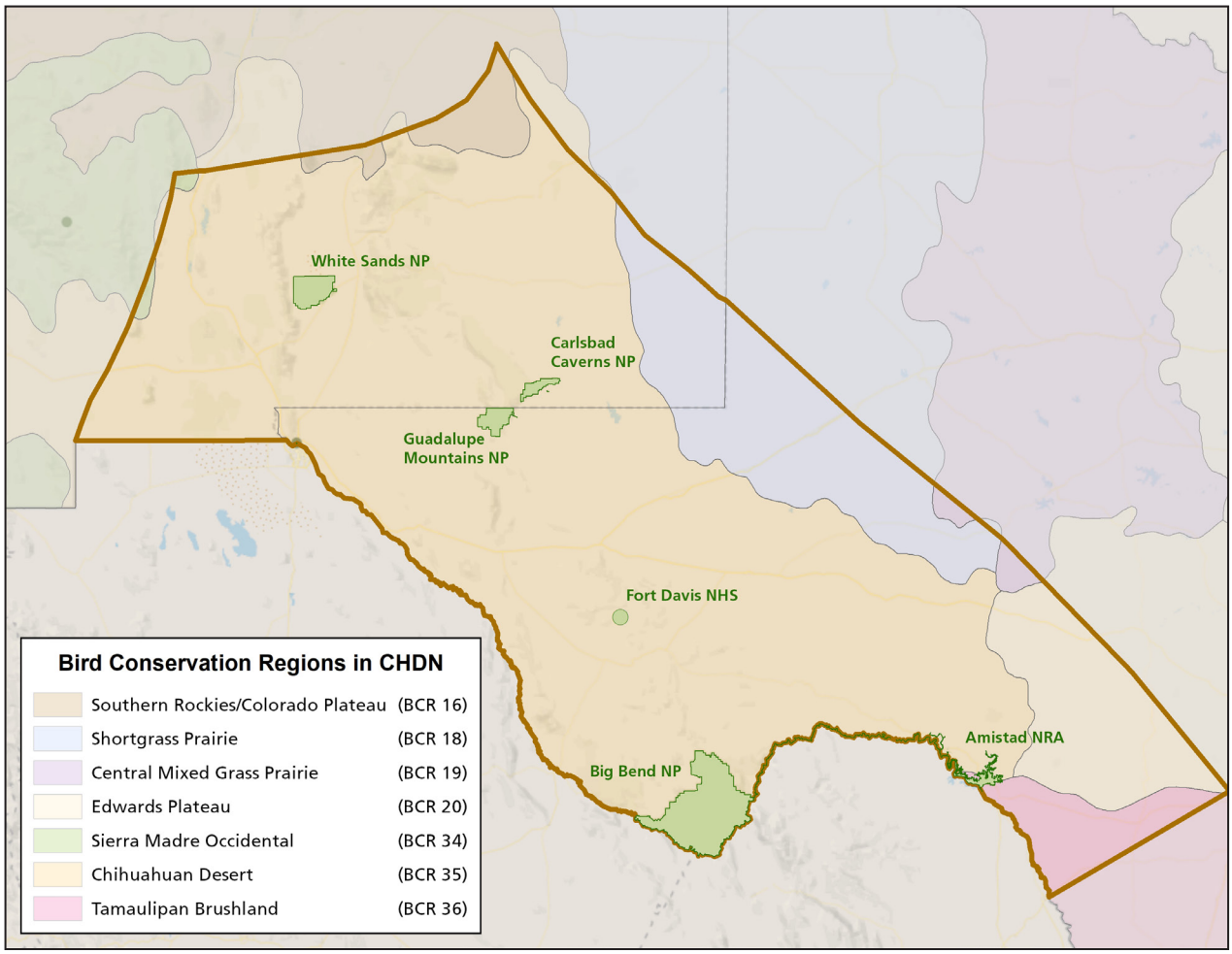


Figure 3-14. Park units within the CHDN, along with the Bird Conservation Regions in network boundaries. Most parks are within BCR 35 (Chihuahuan Desert), with Amistad NRA in both BCR 35 and 36 (Tamaulipan Brushland). Figure credits: NPS Park Tiles (base layer), and Bird Studies Canada and North American Bird Conservation Initiative (for BCRs, 2014).

Table 3-5. Qualitative definitions of possible scores for the Relative Density-Breeding (RD-b) ranking (Panjabi et al. 2020).

RD-b Score	Qualitative Definition
0	Peripheral: has bred only irregularly, or strong evidence of regular breeding is lacking.
1	Breeds regularly but in very small numbers or in only a very small part of the region in question.
2	Breeds in low mean abundance relative to the region(s) in which the species occurs in maximum density.
3	Breeds in moderate mean abundance relative to the region(s) in which the species occurs in maximum density.
4	Breeds in moderately high mean abundance relative to the region(s) in which the species occurs in maximum density.
5	Breeds in high mean abundance, similar to the region(s) in which the species occurs in maximum density.

action taken in regions where the species occurs in highest density will affect the largest number of birds per unit area."

The Percent of Global Population in the Bird Conservation Region (% Pop) indicates the proportion of the global population of the species that is within the region, and it is influenced by the size of the region (in contrast to the RD-b score). This ranking is relevant to a given season, but currently scores are only available for the breeding season. This

score, as opposed to the others, is a continuous variable. This ranking highlights those regions in which conservation/stewardship actions would affect the greatest number of the species. For example, in the following species accounts, the % Pop for Bell's Vireo is 18.4%; this means that nearly one-fifth of the global population of the species occurs within BCR 35 during the breeding season.

The final two regional rankings we used were Regional Concern (RC) and Regional Stewardship (RS). Both RC and RS species must meet all of the criteria in the seasons for which they are listed (currently breeding season only). Species must meet four criteria to be considered an RC species and three criteria to be considered an RS species (Table 3-6). We include these two categories, because, as PIF points out, species that are concentrated within a region also merit stewardship. Partners in Flight (Panjabi et al. 2020) summarizes it as follows:

> It is critical to note that while many species of conservation importance require immediate conservation effort, not every species highlighted from the assessment process should receive the same level of management attention or conservation action in every region. A few species are highlighted, at least in part, because of their relatively high concentration in a region and may be quite common and abundant. These species of "stewardship responsibility" are often missed when assessments consider only local conditions without the context of the global criteria. Partners in Flight identifies these species to support these birds, characteristic of a region, staying common.

Most of the species presented in the species accounts are included because they were detected in numbers high enough to calculate occupancy and density estimates. Such species are less likely to be species of conservation concern. Note that we provide a brief summary of the species that have species accounts that are also considered species of conservation concern in the last section of this chapter (i.e., Section 3.3.2.3).

Table 3-6. Criteria for Regional Concern (RC) and Regional Stewardship (RS) species (Panjabi et al. 2020).

Criteria #	Criteria
RC 1	Regional Combined Score >13; (RCS ranges from 5–25 and includes a total of five global and regional scores).
RC 2	High Regional Threats (>3), or Moderate Regional Threats (3) combined with moderate or large regional population declines (Population Trend-regional >3).
RC 3	Occur regularly in significant numbers in the BCR (i.e., Relative Density >0).
RC 4	Native to North America (not "Introduced" as listed in American Ornithological Society checklist).
RS 1	High importance of the BCR to the species; %Pop >25%.
RS 2	Future conditions are not expected to improve (i.e., Threats during Breeding or Non-breeding Seasons >1).
RS 3	Native to North America (not "Introduced" as listed in American Ornithological Society checklist).

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3.3.1.2 Ash-throated Flycatcher (*Myiarchus cinerascens*)



Ash-throated Flycatcher. Credit: © ROBERT SHANTZ

Ash-throated Flycatcher (*Myiarchus cinerascens*) is a migratory species that breeds in the Chihuahuan Desert and is found in all units of the CHDN (Appendix B). We detected this species in all park units. Ash-throated Flycatcher is an upland generalist, preferring desert scrub, woodland, and riparian habitats (Billerman et al. 2020). This species is one of the more widespread and common species breeding in the CHDN.

Transect occupancy of Ash-throated Flycatcher was high in six of the seven CHDN park-habitats where it was estimated (Table 3-7). Transect occupancy was moderate at White Sands NP (WHSA) Upland. Among species in these park-habitats, the highest Ash-throated Flycatcher ranked in probability of occupying a transect was fourth, at Amistad NRA (AMIS) Riparian and Big Bend NP (BIBE) Riparian. It ranked fifth, sixth, or seventh at the remaining park-habitats.

Unconditional point occupancy was high in Guadalupe Mountains NP (GUMO) Riparian, moderate in Carlsbad Caverns NP (CAVE) Riparian, and low in Fort Davis NHS (FODA) Upland. Among species in these park-habitats, the highest Ash-throated Flycatcher ranked in probability of occupying a point was seventh, in Guadalupe Mountains NP Riparian.

Ash-throated Flycatcher density was highest in Big Bend NP Riparian (0.12 birds/ha [0.09–0.17]), and lowest in White Sands NP Upland (0.02 birds/ha [0.01–0.04]; Table 3-8). Among species in these park-habitats, Ash-throated Flycatcher ranked second in density in Guadalupe Mountains NP Upland. It

Table 3-7. Average occupancy of Ash-throated Flycatcher, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.91 (0.73–0.98)	8	110	7	0.25 (0.18–0.33)	15	110	24
AMIS Riparian	0.79 (0.60–0.95)	12	51	4	0.27 (0.16–0.48)	29	51	28
BIBE Upland	0.88 (0.78–0.96)	5	336	5	0.24 (0.19–0.30)	11	336	10
BIBE Riparian	0.88 (0.74–0.96)	6	106	4	0.33 (0.23–0.47)	18	106	23
CAVE Upland	0.81 (0.64–0.94)	10	108	6	0.28 (0.20–0.39)	17	108	6
CAVE Riparian	–	–	–	–	0.57 (0.37–0.87)	22	24	22
FODA Upland	–	–	–	–	0.24 (0.10–0.44)	34	55	17
GUMO Upland	0.78 (0.65–0.93)	9	116	5	0.24 (0.17–0.32)	16	116	7
GUMO Riparian	–	–	–	–	0.76 (0.55–0.98)	15	46	7
WHSA Upland	0.57 (0.35–0.78)	20	57	5	0.20 (0.12–0.29)	23	57	11

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-8. Average density of Ash-throated Flycatcher in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
AMIS Upland	0.07 (0.06–0.09)	9	145	15
BIBE Riparian	0.12 (0.09–0.17)	18	166	8
BIBE Upland	0.06 (0.05–0.07)	9	604	8
CAVE Upland	0.06 (0.05–0.09)	16	202	8
FODA Upland	0.08 (0.05–0.14)	29	110	5
GUMO Upland	0.06 (0.05–0.08)	13	257	2
WHSA Upland	0.02 (0.01–0.04)	25	107	5

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

ranked in the top ten in five additional park-habitats.

Ash-throated Flycatcher has a low Continental Combined Score (8) in the Avian Conservation Assessment Database (ACAD), as well as low regional population trend (1) and regional threats (2) scores (Table 3-9). The low regional population trend score indicates a significant, large increase, and the relatively low threats score indicates comparatively low vulnerability. Its relative density score is high (5 out of 5), indicating the species breeds in high mean abundance in the region. The percentage of its population in Bird Conservation Region (BCR) 35 is 11.3%. Ash-throated Flycatcher is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability status in the parks.

Table 3-9. Conservation status of Ash-throated Flycatcher at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	8
Federally listed under ESA	no
Regional Population Trend (PT-r)	1
Regional Threats-Breeding (TB-r)	2
Relative Density-Breeding (RD-b)	5
Percent of Global Population in BCR (% Pop)	11.3
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.3 Barn Swallow (*Hirundo rustica*)



Barn Swallow. Credit: © ROBERT SHANTZ

Barn Swallow (*Hirundo rustica*) is a migratory species breeding in all CHDN park units (Appendix B), and we detected this species in all park units. Barn Swallow is a widely distributed species whose breeding habitat consists of open areas where they forage on flying insects (Billerman et al. 2020). Their mud nests can often be found on National Park Service building walls, or on natural walls with overhang substrate.

Transect occupancy of Barn Swallow was moderate at Amistad NRA (AMIS) Upland (Table 3-10). We did not categorize Barn Swallow occupancy (transect or unconditional point occupancy) at other park-habitat combinations because of very low precision in the estimates (i.e., credible interval range >0.50). Among species in Amistad NRA Upland, Barn Swallow did not rank high in probability of occupying a transect.

Based on low detection numbers, we did not estimate density of Barn Swallow for any park-habitat combinations.

Barn Swallow has a low Continental Combined Score (8), and low regional population trend and regional threats scores (2), in the Avian Conservation Assessment Database (ACAD; Table 3-11). Its relative density score is moderate (3 out of 5), indicating the species breeds in moderate mean abundance relative to the region(s) in which it occurs in maximum density. The percentage of its population in Bird Conservation Region (BCR) 35 is less than 1.0%. Barn Swallow is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability status in the parks.

Table 3-10. Average occupancy of Barn Swallow, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.36 (0.17–0.67)	34	26	32	0.78 (0.27–1.00)	27	26	3
CAVE Riparian	–	–	–	–	0.53 (0.23–0.94)	34	14	23
FODA Upland	–	–	–	–	0.67 (0.26–0.94)	28	39	3
GUMO Upland	0.54 (0.26–0.88)	29	13	18	0.14 (0.02–0.49)	71	13	18
WHSA Upland	0.49 (0.30–0.81)	25	18	9	0.53 (0.12–1.00)	47	18	4

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-11. Conservation status of Barn Swallow at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	8
Federally listed under ESA	no
Regional Population Trend (PT-r)	2
Regional Threats-Breeding (TB-r)	2
Relative Density-Breeding (RD-b)	3
Percent of Global Population in BCR (% Pop)	0.1
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
NM Avian Conservation Partners	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.4 Bell's Vireo (*Vireo bellii*)



Bell's Vireo. Credit: ALAN SCHMIERER (PUBLIC DOMAIN VIA BIRDS.COM)

Bell's Vireo (*Vireo bellii*) is found in all CHDN park units and is a migratory species breeding in Amistad NRA, Big Bend NP, and Carlsbad Caverns NP (Appendix B). It possibly breeds in Fort Davis NHS and Guadalupe Mountains NP. We detected Bell's Vireo in all park units except Fort Davis NHS. This species breeds in early successional riparian and wetland habitats with dense, shrubby characteristics (Billerman et al. 2020).

Transect occupancy of Bell's Vireo was high in Amistad NRA (AMIS) Upland, Amistad NRA Riparian, and Big Bend NP (BIBE) Riparian (Table 3-12). Its transect occupancy was moderate in Big Bend NP Upland. Among species in these park-habitats, Bell's Vireo ranked among the highest of all species in probability of occupying a transect at three: Big Bend NP Riparian (first), Amistad NRA Riparian (first), and Amistad NRA Upland (third); at the latter, probably due to the proximity of upland transects to riparian and/or shoreline habitat.

Unconditional point occupancy at Carlsbad Caverns NP (CAVE) Riparian was high. Among species in this park-habitat, Bell's Vireo ranked ninth among species in probability of occupying a point.

Bell's Vireo density was highest in Big Bend NP Riparian (1.10 birds/ha [0.89–1.37]), and next highest in Amistad NRA Riparian (0.44 birds/ha [0.29–0.65]; Table 3-13). Among species in these park-habitats, density of Bell's Vireo ranked first in Big Bend NP Riparian and fourth in Amistad NRA Riparian.

Bell's Vireo has a moderate Continental Combined Score (10) in the Avian Conservation Assessment Database (ACAD; Table 3-14). It has a low regional population trend

Table 3-13. Average density of Bell's Vireo in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
AMIS Upland	0.15 (0.11–0.21)	17	261	9
AMIS Riparian	0.44 (0.29–0.65)	20	153	4
BIBE Upland	0.05 (0.03–0.08)	22	248	10
BIBE Riparian	1.10 (0.89–1.37)	11	598	1

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

Table 3-12. Average occupancy of Bell's Vireo, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.93 (0.75–0.99)	7	173	3	0.30 (0.21–0.41)	17	173	20
AMIS Riparian	0.89 (0.75–0.98)	7	101	1	0.43 (0.31–0.57)	15	101	13
BIBE Upland	0.40 (0.25–0.58)	21	159	23	0.20 (0.12–0.31)	24	159	15
BIBE Riparian	0.94 (0.82–0.99)	5	296	1	0.79 (0.72–0.86)	5	296	1
CAVE Riparian	–	–	–	–	0.82 (0.66–0.95)	9	52	9

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

score (1), which indicates a significant, large increase in population size within the region. Its regional threats score (3) indicates a moderate level of vulnerability. The relative density score (4) means that Bell's Vireo breeds in moderately high mean abundance relative to the region(s) in which it occurs in maximum density. Although the percentage of its population in Bird Conservation Region (BCR) 35 is close to 20% (i.e., 18.4%), it does not meet criteria to be considered of regional concern or a stewardship species. Bell's Vireo is state-listed as threatened in New Mexico.

Due to its threatened status in New Mexico, we assessed its breeding habitat availability in the one New Mexico park where it is known to breed (i.e., Carlsbad Caverns NP). Bell's Vireo has limited breeding habitat availability at this park.

Table 3-14. Conservation status of Bell's Vireo at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	10
Federally listed under ESA	no
Regional Population Trend (PT-r)	1
Regional Threats-Breeding (TB-r)	3
Relative Density-Breeding (RD-b)	4
Percent of Global Population in BCR (% Pop)	18.4
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	T [3]
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

[3] T = Threatened.

3.3.1.5 Bewick's Wren (*Thryomanes bewickii*)



Bewick's Wren. Credit: © ROBERT SHANTZ

Bewick's Wren (*Thryomanes bewickii*) occurs in all CHDN park units. It is a resident species that breeds in all park units except White Sands NP (Appendix B). We detected Bewick's Wren in all park units, but only once in White Sands NP. Its breeding habitat is typically open woodland with a thick, scrubby understory (Billerman et al. 2020).

Transect-level occupancy of Bewick's Wren was high at Amistad NRA (AMIS) Upland, moderate at Amistad NRA Riparian, and low at Guadalupe Mountains NP (GUMO) Upland (Table 3-15). Among species in these park-habitats, the highest Bewick's Wren ranked in probability of occupying a transect was sixth, at Amistad NRA Upland, and eighth, at Amistad NRA Riparian.

Unconditional point-level occupancy was high at Guadalupe Mountains NP Riparian, possibly influenced by adjacent hillsides of its preferred habitat. Unconditional point occupancy was low at Fort Davis NHS Upland. Among species in these park-habitats, Bewick's Wren did not rank high in probability of occupying a point.

Bewick's Wren density was estimated only for Amistad NRA Upland (0.15 birds/ha [0.09–0.23]; Table 3-16). Bewick's Wren ranked tenth in estimated density among all species detected in this park-habitat.

Bewick's Wren has a moderate Continental Combined Score (11) in the Avian Conservation Assessment Database (ACAD; Table 3-17). It has moderate scores (out of 5 each) for regional population trend (3), regional threats (3), and relative density (3). The rela-

Table 3-16. Average density of Bewick's Wren in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
AMIS Upland	0.15 (0.09–0.23)	22	139	10

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

Table 3-15. Average occupancy of Bewick's Wren, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.91 (0.75–0.99)	7	111	6	0.26 (0.15–0.44)	28	111	23
AMIS Riparian	0.66 (0.43–0.90)	18	29	8	0.37 (0.12–0.81)	46	29	18
BIBE Upland	0.37 (0.18–0.77)	38	33	24	0.05 (0.01–0.20)	80	33	24
CAVE Upland	0.55 (0.28–0.87)	28	25	15	0.09 (0.03–0.28)	61	25	19
CAVE Riparian	–	–	–	–	0.34 (0.16–0.83)	44	10	25
FODA Upland	–	–	–	–	0.21 (0.06–0.51)	50	32	19
GUMO Upland	0.27 (0.11–0.55)	41	27	26	0.19 (0.05–0.47)	52	27	13
GUMO Riparian	–	–	–	–	0.70 (0.50–0.91)	15	52	12

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

tive density score means that it breeds in moderate mean abundance relative to the region(s) in which it occurs in maximum density. The percentage of its population in Bird Conservation Region (BCR) 35 is small (3.7%). This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability in the parks.

Table 3-17. Conservation status of Bewick's Wren at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	11
Federally listed under ESA	no
Regional Population Trend (PT-r)	3
Regional Threats-Breeding (TB-r)	3
Relative Density-Breeding (RD-b)	3
Percent of Global Population in BCR (% Pop)	3.7
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.6 Black Phoebe (*Sayornis nigricans*)



Black Phoebe. Credit: GARY KRAMER, USFWS

Black Phoebe (*Sayornis nigricans*) is an occasional migrant at White Sands NP and a resident breeding species at all other CHDN park units (Appendix B). We detected Black Phoebe at Amistad NRA, Big Bend NP, Carlsbad Caverns NP, and Guadalupe Mountains NP. Its breeding habitat is typical of open areas associated with rivers, streams, or other water sources (Billerman et al. 2020).

Although we estimated transect occupancy of Black Phoebe at two park-habitats (Table 3-18), we did not categorize it (high, moderate, or low) because of very low precision in the estimates (i.e., credible interval range >0.50).

Based on low detection numbers, we did not estimate density of Black Phoebe for any park-habitat combinations.

Black Phoebe has a low Continental Combined Score (8) in the Avian Conservation Assessment Database (ACAD; Table 3-19). The species also has low regional population trend (2) and relative density (2) scores. Its regional threats score is moderate (3). The percentage of its global population in Bird Conservation Region (BCR) 35 is less than 1.0%. Black Phoebe is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability status in the parks.

Table 3-18. Average occupancy of Black Phoebe, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Riparian	0.46 (0.19–0.80)	34	10	28	0.46 (0.09–0.93)	48	10	9
BIBE Riparian	0.66 (0.41–0.92)	20	29	14	0.56 (0.14–0.96)	39	29	7

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.
Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-19. Conservation status of Black Phoebe at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	8
Federally listed under ESA	no
Regional Population Trend (PT-r)	2
Regional Threats-Breeding (TB-r)	3
Relative Density-Breeding (RD-b)	2
Percent of Global Population in BCR (% Pop)	0.7
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
NM Avian Conservation Partners	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.7 Black-chinned Hummingbird (*Archilochus alexandri*)



Black-chinned Hummingbird. Credit: ALAN SCHMIERER, USFWS

Black-chinned Hummingbird (*Archilochus alexandri*) is a migratory species that breeds in all CHDN park units (Appendix B), and we detected it in all park units during surveys. Its breeding habitat is typically in drier canyons, washes, or riparian woodlands, as well as in lowland areas and along the Rio Grande (Billerman et al. 2020).

We did not categorize transect occupancy (high, moderate, low) of Black-chinned Hummingbird at any park-habitats because of very low precision in the estimates (i.e., credible interval range >0.50; Table 3-20). Unconditional point occupancy was high at Carlsbad Caverns NP (CAVE) Riparian. Among species in this park-habitat, Black-chinned Hummingbird ranked seventh in probability of occupying a point.

Based on low detection numbers, we did not estimate density of Black-chinned Hummingbird for any park-habitats.

Black-chinned Hummingbird has a moderate Continental Combined Score (9), as well as low regional population trend (2) and regional threats (2) scores, in the Avian Conservation Assessment Database (ACAD) (Table 3-21). The relative density score is comparatively high (4 out of 5), indicating the species breeds in moderately high mean abundance relative to the region(s) in which it occurs in maximum density. The percentage of its population in Bird Conservation Region (BCR) 35 is 12.0%. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability in the parks.

Table 3-20. Average occupancy of Black-chinned Hummingbird, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Riparian	0.51 (0.25–0.83)	29	11	24	0.45 (0.11–0.91)	45	11	11
BIBE Riparian	0.49 (0.23–0.81)	28	10	25	0.27 (0.05–0.73)	60	10	26
CAVE Riparian	–	–	–	–	0.84 (0.54–0.99)	15	19	7
FODA Upland	–	–	–	–	0.73 (0.31–0.95)	24	34	1

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-21. Conservation status of Black-chinned Hummingbird at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	9
Federally listed under ESA	no
Regional Population Trend (PT-r)	2
Regional Threats-Breeding (TB-r)	2
Relative Density-Breeding (RD-b)	4
Percent of Global Population in BCR (% Pop)	12.0
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
NM Avian Conservation Partners	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F.)

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.8 Black-chinned Sparrow (*Spizella atrogularis*)



Black-chinned Sparrow. Credit: © ROBERT SHANTZ

Black-chinned Sparrow (*Spizella atrogularis*) is a resident species breeding in Big Bend NP, Carlsbad Caverns NP, Fort Davis NHS, and Guadalupe Mountains NP (Appendix B). It is a non-breeder at Amistad NRA and White Sands NP. We detected Black-chinned Sparrow only in parks in which it breeds. Black-chinned Sparrow's breeding habitat is typically on mountain slopes and in foothills with dry shrubland (Billerman et al. 2020).

This species is behaviorally "shy" (Benson and Arnold 2001), inconspicuous, and partially to fully migratory (except for small pockets of resident populations) across CHDN parks (Billerman et al. 2020), perhaps contributing to fewer detections during surveys (see below).

We did not detect Black-chinned Sparrow in sufficient numbers in any park-habitat combination to allow estimation of transect occupancy. Although we were able to estimate unconditional point occupancy of Black-chinned Sparrow in Guadalupe Mountains NP (GUMO) Riparian (Table 3-22), occupancy was not categorized because of very low precision in the estimate (i.e., credible interval range >0.50).

Based on low detection numbers, we did not estimate density of Black-chinned Sparrow for any park-habitat combinations.

Black-chinned Sparrow has a moderate Continental Combined Score (14), and moderate regional population trend (3) and regional threats (3) scores, representing a moderate level of vulnerability, in the Avian Conservation Assessment Database (ACAD; Table 3-23). The relative density score is comparatively high (4 out of 5), indicating the species breeds in moderately high mean abundance relative to the region(s) in which it occurs in maximum density. This species is not listed under any of the remaining conservation status categories in Table 3-23. However, as discussed in Section 3.1 of the report, Black-chinned Sparrow is a Continental Watch List species (Rosenberg et al. 2016), and we therefore consider it a species of conservation concern. As mentioned previously, the species is known to breed in four CHDN parks. Of these, we consider there to be extensive breeding habitat available for the species at Carlsbad Caverns NP, and moderate breeding habitat availability at Big Bend NP, Fort Davis NHS, and Guadalupe Mountains NP.

Table 3-22. Average occupancy of Black-chinned Sparrow, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
GUMO Riparian	–	–	–	–	0.75 (0.38–0.98)	23	21	9

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-23. Conservation status of Black-chinned Sparrow at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	14
Federally listed under ESA	no
Regional Population Trend (PT-r)	3
Regional Threats-Breeding (TB-r)	3
Relative Density-Breeding (RD-b)	4
Percent of Global Population in BCR (% Pop)	3.8
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
NM Avian Conservation Partners	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.9 Black-tailed Gnatcatcher (*Polioptila melanura*)



Black-tailed Gnatcatcher. Credit: © ROBERT SHANTZ

Black-tailed Gnatcatcher (*Polioptila melanura*) is a resident species breeding in all park units of the CHDN, except in Carlsbad Caverns NP where it is a possible breeder (Appendix B). We detected Black-tailed Gnatcatcher in all park units. This species breeds in dense desert scrub along washes or on alluvial terraces (Billerman et al. 2020).

Transect occupancy of Black-tailed Gnatcatcher was high at Big Bend NP (BIBE) Upland and moderate at Amistad NRA (AMIS) Upland (Table 3-24). Among species in these park-habitats, the highest Black-tailed Gnatcatcher ranked in probability of occupying a transect was second (at Big Bend NP Upland).

Density of Black-tailed Gnatcatcher was 0.26 birds/ha (0.20–0.33) at Big Bend NP Upland (Table 3-25). Among species in this park-habitat, it ranked second in density. Due to low detection numbers, we did not estimate density in any other park-habitats.

Black-tailed Gnatcatcher has a moderate Continental Combined Score (9) in the Avian Conservation Assessment Database (ACAD), as well as low regional population trend (2) and moderate regional threats (3) scores (Table 3-26). The relative density score (5) indicates that the species breeds in high mean abundance, similar to the region(s) in which it occurs in maximum density. The percentage of its population in Bird Conservation Region (BCR) 35 is 17.1%. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability status in the parks.

Table 3-25. Average density of Black-tailed Gnatcatcher in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
BIBE Upland	0.26 (0.20–0.33)	12	417	2

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

Table 3-24. Average occupancy of Black-tailed Gnatcacher, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.39 (0.21–0.68)	30	26	31	0.25 (0.06–0.88)	69	26	25
BIBE Upland	0.91 (0.78–0.98)	6	352	2	0.24 (0.17–0.36)	20	352	11
BIBE Riparian	0.59 (0.35–0.89)	23	29	19	0.49 (0.13–0.95)	45	29	12
GUMO Upland	0.68 (0.41–0.95)	22	18	12	0.06 (0.02–0.27)	82	18	24

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-26. Conservation status of Black-tailed Gnatcatcher at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	9
Federally listed under ESA	no
Regional Population Trend (PT-r)	2
Regional Threats-Breeding (TB-r)	3
Relative Density-Breeding (RD-b)	5
Percent of Global Population in BCR (% Pop)	17.1
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
NM Avian Conservation Partners	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.10 Black-throated Sparrow (*Amphispiza bilineata*)



Black-throated Sparrow. Credit: © ROBERT SHANTZ

Black-throated Sparrow (*Amphispiza bilineata*) is a resident species that breeds in all park units of the CHDN (Appendix B), and we detected this species in all park units. Black-throated Sparrow breeds in semi-open shrubland, often associated with creosote bush (*Larrea tridentata;* Billerman et al. 2020).

Transect occupancy of Black-throated Sparrow was high at Amistad NRA (AMIS) Upland, Big Bend NP (BIBE) Upland, Big Bend NP Riparian, Carlsbad Caverns NP (CAVE) Upland, Guadalupe Mountains NP (GUMO) Upland, and White Sands NP (WHSA) Upland (Table 3-27). Occupancy of Black-throated Sparrow in Big Bend NP Upland, Carlsbad Caverns NP Upland, Guadalupe Mountains NP Upland, and White Sands NP Upland ranked first among all species in these park-habitats in probability of occupying a transect. At Amistad NRA Upland, Black-throated Sparrow ranked second.

Unconditional point occupancy of Black-throated Sparrow at Fort Davis NHS (FODA) Upland was moderate. Among species in this park-habitat, Black-throated Sparrow ranked sixth.

Black-throated Sparrow density was highest in Big Bend NP Upland (0.83 birds/ha [0.74–0.94]), Carlsbad Caverns NP Upland (0.82 birds/ha [0.68–1.00]), Amistad NRA Upland (0.70 birds/ha [0.58–0.86]), and Guadalupe Mountains NP Upland (0.70 birds/ha [0.57–0.86]), and lowest in White Sands NP Upland (0.33 birds/ha [0.26–0.42]) and Fort Davis NHS Upland (0.46 birds/ha [0.31–0.67]; Table 3-28). Black-throated Sparrow ranked highest in density among species in all park Upland transects, except Amistad NRA Upland (ranked second). Although density estimates were lowest at Fort Davis NHS Upland and White Sands NP Upland, Black-throated Sparrow still ranked highest at each of these park-habitats.

Black-throated Sparrow has a moderate Continental Combined Score (9) in the Avian Conservation Assessment Database (ACAD),

Table 3-27. Average occupancy of Black-throated Sparrow, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.95 (0.80–0.99)	5	311	2	0.69 (0.58–0.78)	7	311	5
AMIS Riparian	0.57 (0.30–0.86)	26	20	19	0.45 (0.15–0.90)	43	20	10
BIBE Upland	0.98 (0.90–1.00)	3	1,112	1	0.73 (0.66–0.78)	4	1,112	2
BIBE Riparian	0.75 (0.56–0.93)	13	63	9	0.76 (0.28–0.99)	29	63	2
CAVE Upland	0.95 (0.78–0.99)	6	382	1	0.83 (0.73–0.90)	5	382	1
FODA Upland	–	–	–	–	0.53 (0.23–0.73)	25	91	6
GUMO Upland	0.92 (0.80–0.98)	5	377	1	0.70 (0.61–0.79)	6	377	2
WHSA Upland	0.88 (0.74–0.97)	7	329	1	0.66 (0.54–0.75)	8	329	2

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-28. Average density of Black-throated Sparrow in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
BIBE Upland	0.83 (0.74–0.94)	6	2,167	1
FODA Upland	0.46 (0.31–0.67)	19	161	1
WHSA Upland	0.33 (0.26–0.42)	12	631	1

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

as well as a low regional threats score (2; Table 3-29). Its regional population trend score of 5 indicates a significantly large decrease in population size within the region. For relative density, the score (5) indicates that it breeds in high mean abundance, similar to the region(s) in which it occurs in maximum density. The percentage of its population in Bird Conservation Region (BCR) 35 is 11.7%. Black-throated Sparrow is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability status in the parks.

Table 3-29. Conservation status of Black-throated Sparrow at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	9
Federally listed under ESA	no
Regional Population Trend (PT-r)	5
Regional Threats-Breeding (TB-r)	2
Relative Density-Breeding (RD-b)	5
Percent of Global Population in BCR (% Pop)	11.7
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.11 Blue Grosbeak (*Passerina caerulea*)



Blue Grosbeak. Credit: © ROBERT SHANTZ

Blue Grosbeak (*Passerina caerulea*) is a migratory species that breeds in all park units of the CHDN (Appendix B). We detected this species in all park units. Blue Grosbeak breeds in diverse habitats of open grassland with shrub and tree components (Benson and Arnold 2001).

Transect occupancy of Blue Grosbeak was high at Carlsbad Caverns NP (CAVE) Upland and moderate at Amistad NRA (AMIS) Riparian (Table 3-30). It was low at Big Bend NP (BIBE) Riparian and White Sands NP (WHSA) Upland. Blue Grosbeak ranked second highest of all species in probability of occupying a transect at Carlsbad Caverns NP Upland.

Although we estimated unconditional point occupancy of Blue Grosbeak at Carlsbad Caverns NP Riparian, we did not categorize it (high, moderate, or low) because of very low precision in the estimate (i.e., credible interval range >0.50).

Blue Grosbeak density was only available for Carlsbad Caverns NP Upland, where it was estimated at 0.10 birds/ha (0.07–0.15) and ranked fifth among all species detected in that park-habitat combination (Table 3-31).

Blue Grosbeak has a low Continental Combined Score (8) in the Avian Conservation Assessment Database (ACAD), as well as a low regional population trend score (1) and a moderate regional threats score (3; Table 3-32). For relative density, the score (5) indicates that it breeds in high mean abundance, similar to the region(s) in which it occurs in maximum density. The percentage of its population in Bird Conservation Region (BCR) 35 is 5.3%. Blue Grosbeak is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability status in the parks.

Table 3-30. Average occupancy of Blue Grosbeak, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.63 (0.37–0.90)	22	41	27	0.16 (0.06–0.35)	43	41	29
AMIS Riparian	0.56 (0.36–0.81)	20	27	20	0.47 (0.19–0.87)	36	27	7
BIBE Riparian	0.22 (0.14–0.44)	34	36	31	0.58 (0.23–0.93)	32	36	6
CAVE Upland	0.87 (0.64–0.98)	11	114	2	0.25 (0.14–0.42)	27	114	9
CAVE Riparian	–	–	–	–	0.58 (0.28–0.96)	31	15	21
GUMO Upland	0.47 (0.26–0.78)	26	15	21	0.09 (0.02–0.25)	62	15	22
WHSA Upland	0.30 (0.13–0.56)	35	25	15	0.23 (0.08–0.59)	51	25	9

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-31. Average density of Blue Grosbeak in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
CAVE Upland	0.10 (0.07–0.15)	21	222	5

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

Table 3-32. Conservation status of Blue Grosbeak at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	8
Federally listed under ESA	no
Regional Population Trend (PT-r)	1
Regional Threats-Breeding (TB-r)	3
Relative Density-Breeding (RD-b)	5
Percent of Global Population in BCR (% Pop)	5.3
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
NM Avian Conservation Partners	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.12 Blue-gray Gnatcatcher (*Polioptila caerulea*)



Blue-gray Gnatcatcher. Credit: © ROBERT SHANTZ

Blue-gray Gnatcatcher (*Polioptila caerulea*) is a migratory species breeding in all park units of the CHDN, except Fort Davis NHS and White Sands NP (Appendix B). We detected this species in all park units. Blue-gray Gnatcatcher breeds in a variety of wooded scrub habitats (Billerman et al. 2020) and in oaks (*Quercus* spp.) in Texas (Benson and Arnold 2001).

Transect occupancy of Blue-gray Gnatcatcher was high at Big Bend NP (BIBE) Upland and moderate at Amistad NRA (AMIS) Upland (Table 3-33). Despite these moderate to high estimates of occupancy, Blue-gray Gnatcatcher was not among the top 10 species at either park-habitat in its rank for probability of occupying a transect.

Unconditional point occupancy of Blue-gray Gnatcatcher was high at Guadalupe Mountains NP (GUMO) Riparian. Among species in this park-habitat, Blue-gray Gnatcatcher ranked eighth in unconditional point occupancy. It is likely that this high occupancy is due to the close proximity of woodland scrub to the riparian transect.

Based on low detection numbers, we did not estimate the density of Blue-gray Gnatcatcher for any park-habitat combinations.

Blue-gray Gnatcatcher has a low Continental Combined Score (7) in the Avian Conservation Assessment Database (ACAD), as well as a low relative density score (2; Table 3-34). It has moderate scores (out of 5) for regional population trend (3) and regional threats (3). The percentage of its population in Bird Conservation Region (BCR) 35 is a very low 0.1%. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability status in the parks.

Table 3-33. Average occupancy of Blue-gray Gnatcatcher, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.65 (0.42–0.90)	20	24	25	0.40 (0.06–1.00)	65	24	14
BIBE Upland	0.69 (0.48–0.92)	16	85	12	0.45 (0.09–0.91)	54	85	5
BIBE Riparian	0.57 (0.34–0.87)	23	21	21	0.47 (0.12–0.92)	45	21	13
GUMO Riparian	–	–	–	–	0.76 (0.49–0.97)	17	36	8

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-34. Conservation status of Blue-gray Gnatcatcher at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	7
Federally listed under ESA	no
Regional Population Trend (PT-r)	3
Regional Threats-Breeding (TB-r)	3
Relative Density-Breeding (RD-b)	2
Percent of Global Population in BCR (% Pop)	0.1
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
NM Avian Conservation Partners	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.13 Brown-headed Cowbird (*Molothrus ater*)



Brown-headed Cowbird. Credit: © ROBERT SHANTZ

Brown-headed Cowbird (*Molothrus ater*) is a migratory species that breeds in all park units of the CHDN (Appendix B). We detected this species in all park units. Brown-headed Cowbird typically breeds in grassland-woodland edge habitats (Billerman et al. 2020), but it is found regularly in desert habitats as well. It is a nest parasite to species such as Black-tailed Gnatcatcher, Blue Grosbeak, Black-throated Sparrow, Canyon Towhee (Kozma and Mathews 1997), and Bell's Vireo (Billerman et al. 2020), depositing eggs in their nests and leaving young to be raised by the host species. This results in reduced survival of the host's own young.

Transect occupancy of Brown-headed Cowbird was high at Amistad NRA (AMIS) Upland and Guadalupe Mountains NP (GUMO) Upland, and moderate at Big Bend NP (BIBE) Riparian and Carlsbad Caverns NP (CAVE) Upland (Table 3-35). Among species in these park-habitats, the highest Brown-headed Cowbird ranked in probability of occupying a transect was eighth—at Guadalupe Mountains NP Upland.

Unconditional point occupancy of Brown-headed Cowbird was high at Carlsbad Caverns NP Riparian and low at Guadalupe Mountains NP Riparian.

Brown-headed Cowbird density was estimated only for Amistad NRA Upland transects, where it was 0.20 birds/ha (0.11–0.36). It ranked sixth among all species detected in this park-habitat combination (Table 3-36).

Brown-headed Cowbird has a low Continental Combined Score (7), as well as a low regional threats score (2), in the Avian Conservation Assessment Database (ACAD; Table 3-37). It has a moderate score for relative

Table 3-35. Average occupancy of Brown-headed Cowbird, by transect and point, in CHDN parks and habitats, 2010-2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.80 (0.65–0.93)	9	133	13	0.77 (0.42–1.00)	24	133	4
AMIS Riparian	0.64 (0.38–0.90)	21	37	10	0.39 (0.09–0.84)	49	37	17
BIBE Upland	0.44 (0.18–0.80)	35	21	22	0.07 (0.02–0.34)	82	21	21
BIBE Riparian	0.41 (0.25–0.66)	25	28	28	0.36 (0.07–0.86)	55	28	20
CAVE Upland	0.65 (0.45–0.92)	19	29	12	0.30 (0.09–0.97)	63	29	5
CAVE Riparian	–	–	–	–	0.81 (0.61–0.98)	12	41	12
GUMO Upland	0.73 (0.45–0.93)	17	15	8	0.11 (0.03–0.51)	82	15	20
GUMO Riparian	–	–	–	–	0.31 (0.16–0.66)	38	15	22

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-36. Average density of Brown-headed Cowbird in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
AMIS Upland	0.20 (0.11–0.36)	28	282	6

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

density (3), and a comparatively high score (4 out of 5) for regional population trend (meaning there has been a large decrease in population size in the region). The percent of its population in Bird Conservation Region (BCR) 35 is a very low 0.9%. Brown-headed Cowbird is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability status in the parks.

Table 3-37. Conservation status of Brown-headed Cowbird at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	7
Federally listed under ESA	no
Regional Population Trend (PT-r)	4
Regional Threats-Breeding (TB-r)	2
Relative Density-Breeding (RD-b)	3
Percent of Global Population in BCR (% Pop)	0.9
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.14 Cactus Wren (*Campylorhynchus brunneicapillus*)



Cactus Wren. Credit: GARY STOLZ, USFWS

Cactus Wren (*Campylorhynchus brunneicapillus*) is a resident species that breeds in all park units of the CHDN (Appendix B), and we detected this species in all park units. In the Chihuahuan Desert, Cactus Wren breeds in shrubland/grassland habitats consisting of mesquite (*Prosopis* spp.), cholla (*Cylindropuntia* spp.), soaptree yucca (*Yucca elata*), and/or creosote bush scrub (Billerman et al. 2020).

Transect occupancy of Cactus Wren was high at Amistad NRA (AMIS) Upland, Big Bend NP (BIBE) Upland, and Guadalupe Mountains NP (GUMO) Upland, and moderate at White Sands NP (WHSA) Upland (Table 3-38). At Big Bend NP Upland, Cactus Wren ranked third among all species in probability of transect occupancy. Unconditional point occupancy at Fort Davis NHS (FODA) Upland was low, and it did not rank high among species at this park-habitat.

Cactus Wren density was similarly low in Amistad NRA Upland, Big Bend NP Upland, and Guadalupe Mountains NP Upland (between 0.03 birds/ha [0.02–0.04] and 0.18 birds/ha [0.13–0.23]; Table 3-39). Among all species for which density was estimated in Big Bend NP Upland, Cactus Wren ranked third.

Cactus Wren has a moderate Continental Combined Score (12), and a moderate regional threats score (3), in the Avian Conservation Assessment Database (ACAD; Table 3-40). Its regional population trend score (5

Table 3-39. Average density of Cactus Wren in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
AMIS Upland	0.18 (0.13–0.23)	14	354	8
BIBE Upland	0.14 (0.12–0.16)	7	1689	3
GUMO Upland	0.03 (0.02–0.04)	18	189	6

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

Table 3-38. Average occupancy of Cactus Wren, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.89 (0.71–0.98)	8	227	9	0.47 (0.36–0.58)	12	227	10
AMIS Riparian	0.42 (0.20–0.71)	30	12	30	0.36 (0.06–0.87)	55	12	20
BIBE Upland	0.90 (0.78–0.96)	5	692	3	0.43 (0.36–0.51)	8	692	6
CAVE Upland	0.33 (0.14–0.66)	39	19	20	0.10 (0.03–0.33)	64	19	18
FODA Upland	–	–	–	–	0.22 (0.08–0.43)	39	40	18
GUMO Upland	0.69 (0.50–0.89)	14	63	10	0.15 (0.08–0.26)	30	63	17
WHSA Upland	0.37 (0.17–0.64)	32	16	13	0.08 (0.02–0.22)	60	16	16

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-40. Conservation status of Cactus Wren at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	12
Federally listed under ESA	no
Regional Population Trend (PT-r)	5
Regional Threats-Breeding (TB-r)	3
Relative Density-Breeding (RD-b)	5
Percent of Global Population in BCR (% Pop)	11.8
Regional Concern	yes
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

out of 5) indicates high vulnerability due to a significant, large decrease. The relative density score for this species (5) indicates that it breeds in high mean abundance within the region, similar to the region in which it occurs in maximum density. The percentage of its population in Bird Conservation Region (BCR) 35 is 11.8%. Cactus Wren meets the criteria to be considered a regional concern species. However, this species is not listed under any of the remaining conservation status categories in the table. Because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability status in the parks.

3.3.1.15 Canyon Towhee (*Melozone fusca*)



Canyon Towhee. Credit: © ROBERT SHANTZ

Canyon Towhee (*Melozone fusca*) is a resident species breeding in all park units of the CHDN (Appendix B). We detected this species in all park units except White Sands NP, where it is considered rare. It breeds in rough, rocky habitats of the Chihuahuan Desert (Benson and Arnold 2001).

Transect occupancy of Canyon Towhee was high at Amistad NRA (AMIS) Upland and Carlsbad Caverns NP (CAVE) Upland, and moderate at Big Bend NP (BIBE) Upland and Guadalupe Mountains NP (GUMO) Upland (Table 3-41). At Carlsbad Caverns NP Upland, Canyon Wren ranked seventh among all species in probability of occupying a transect. Although we estimated unconditional point occupancy of Canyon Towhee at Fort Davis NHS (FODA) Upland and Guadalupe Mountains NP Riparian, we did not categorize occupancy (high, moderate, or low) because of very low precision in the estimates (i.e., credible interval range >0.50).

Density of Canyon Towhee was estimated only at Big Bend NP Upland (0.03 birds/ha [0.02–0.05]; Table 3-42). Among species in this park-habitat, Canyon Towhee did not rank high in density.

Table 3-42. Average density of Canyon Towhee in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
BIBE Upland	0.03 (0.02–0.05)	26	106	12

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

Table 3-41. Average occupancy of Canyon Towhee, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.71 (0.44–0.91)	17	57	19	0.22 (0.10–0.43)	37	57	27
BIBE Upland	0.46 (0.29–0.69)	23	80	21	0.17 (0.07–0.35)	41	80	16
CAVE Upland	0.78 (0.56–0.96)	14	49	7	0.22 (0.11–0.48)	40	49	11
FODA Upland	–	–	–	–	0.33 (0.11–0.68)	43	69	14
GUMO Upland	0.47 (0.23–0.73)	27	34	22	0.21 (0.09–0.45)	41	34	9
GUMO Riparian	–	–	–	–	0.51 (0.26–0.91)	32	12	20

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Canyon Towhee has a moderate Continental Combined Score (9), and a low regional threats score (2), in the Avian Conservation Assessment Database (ACAD; Table 3-43). Its regional population trend score (4 out of 5) indicates moderate to high vulnerability (i.e., a population decrease). The relative density score (4) for this species indicates that it breeds in moderately high mean abundance relative to the region(s) in which it occurs in maximum density. The percentage of its population in Bird Conservation Region (BCR) 35 is 9.9%. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability in the parks.

Table 3-43. Conservation status of Canyon Towhee at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	9
Federally listed under ESA	no
Regional Population Trend (PT-r)	4
Regional Threats-Breeding (TB-r)	2
Relative Density-Breeding (RD-b)	4
Percent of Global Population in BCR (% Pop)	9.9
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.16 Canyon Wren (*Catherpes mexicanus*)



Canyon Wren. Credit: © ROBERT SHANTZ

Canyon Wren (*Catherpes mexicanus*) is a resident species that breeds in all park units of the CHDN except for White Sands NP (Appendix B), where it is an occasional migrant (i.e., it occurs at least once every few years, but not necessarily every year). We detected this species in all park units; however, we observed only one individual in White Sands NP. Canyon Wren breeds in habitats with rocky outcrops and steep canyons (Billerman et al. 2020).

Transect occupancy of Canyon Wren was high at Amistad NRA (AMIS) Riparian and ranked third highest among all species in this park-habitat (Table 3-44). Unconditional point occupancy of Canyon Wren at Fort Davis NHS (FODA) Upland was moderate and did not rank high among species.

Canyon Wren density was low in Amistad NRA Riparian (0.13 birds/ha [0.09–0.19]) and Fort Davis NHS Upland (0.08 birds/ha [0.06–0.10]), the only two park-habitat combinations for which we were able to estimate density (Table 3-45). Among all species detected in Fort Davis NHS Upland and in Amistad NRA Riparian, Canyon Wren ranked fourth and fifth, respectively, in density.

Canyon Wren has a low Continental Combined Score (8) in the Avian Conservation Assessment Database (ACAD), as well as low regional population trend (2) and regional threats (2) scores (Table 3-46). Its relative density score (5) indicates that it breeds in high mean abundance, similar to the region(s) in which it occurs in maximum density. The

Table 3-45. Average density of Canyon Wren in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
AMIS Riparian	0.13 (0.09–0.19)	19	190	5
FODA Upland	0.08 (0.06–0.10)	11	220	4

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

Table 3-44. Average occupancy of Canyon Wren, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Riparian	0.81 (0.61–0.96)	11	72	3	0.35 (0.19–0.57)	26	72	21
BIBE Riparian	0.49 (0.21–0.83)	32	13	26	0.13 (0.03–0.54)	78	13	29
FODA Upland	–	–	–	–	0.35 (0.13–0.58)	33	78	12
GUMO Riparian	–	–	–	–	0.70 (0.34–0.98)	26	21	14

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

percentage of its population in Bird Conservation Region (BCR) 35 is 6.8%. Canyon Wren is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability status in the parks.



Canyon Wren nest. Credit: NPS / KEVIN WELSH

Table 3-46. Conservation status of Canyon Wren at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	8
Federally listed under ESA	no
Regional Population Trend (PT-r)	2
Regional Threats-Breeding (TB-r)	2
Relative Density-Breeding (RD-b)	5
Percent of Global Population in BCR (% Pop)	6.8
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.17 Cassin's Kingbird (*Tyrannus vociferans*)



Cassin's Kingbird. Credit: JOHN J MOSESSO, USGS

Cassin's Kingbird (*Tyrannus vociferans*) is a migratory species breeding in all park units of the CHDN, except for Amistad NRA and White Sands NP (Appendix B). We detected this species in all park units. Cassin's Kingbird breeds in diverse open habitats, but typically in grasslands with shrub, oak, and juniper (*Juniperus* spp.) components (Benson and Arnold 2001).

Transect occupancy of Cassin's Kingbird was not estimated due to a low number of detections. Unconditional point occupancy of Cassin's Kingbird was high at Carlsbad Caverns NP (CAVE) Riparian (Table 3-47). It ranked fifth among all species in this park-habitat in probability of occupying a point. Although we estimated unconditional point occupancy of Cassin's Kingbird at Fort Davis NHS (FODA) Upland and Guadalupe Mountains NP (GUMO) Riparian, we did not categorize occupancy (high, moderate, low) because of very low precision in the estimates (i.e., credible interval range >0.50).

Density of Cassin's Kingbird was estimated at one park-habitat combination, Fort Davis NHS Upland (0.04 birds/ha [0.03–0.06]; Table 3-48). Cassin's Kingbird ranked seventh in density among all species detected in this park-habitat.

Cassin's Kingbird has a moderate Continental Combined Score (9) in the Avian Conservation Assessment Database (ACAD), as well as low regional population trend (2) and regional threats (2) scores (Table 3-49). Its relative density score (4) indicates that it breeds in moderately high mean abundance relative to the region(s) in which it occurs in maximum density. The percentage of its population in Bird Conservation Region (BCR) 35 is 6.4%. This species is not listed under any of the remaining conservation status categories

Table 3-48. Average density of Cassin's Kingbird in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
FODA Upland	0.04 (0.03–0.06)	20	104	7

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

Table 3-47. Average occupancy of Cassin's Kingbird, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
CAVE Riparian	–	–	–	–	0.93 (0.76–1.00)	7	57	5
FODA Upland	–	–	–	–	0.71 (0.25–0.95)	28	40	2
GUMO Riparian	–	–	–	–	0.46 (0.23–0.78)	30	22	21

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability in the parks.

Table 3-49. Conservation status of Cassin's Kingbird at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	9
Federally listed under ESA	no
Regional Population Trend (PT-r)	2
Regional Threats-Breeding (TB-r)	2
Relative Density-Breeding (RD-b)	4
Percent of Global Population in BCR (% Pop)	6.4
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
NM Avian Conservation Partners	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.18 Cassin's Sparrow (*Peucaea cassinii*)



Cassin's Sparrow. Credit: ALAN SCHMIERER (PUBLIC DOMAIN, BIRDPHOTOS.COM)

Cassin's Sparrow (*Peucaea cassinii*) is a migratory species that breeds in all park units of the CHDN (Appendix B), and we detected this species in all park units. Cassin's Sparrow breeds in grasslands with scattered shrubs, low trees, and yuccas (Billerman et al. 2020).

Transect occupancy of Cassin's Sparrow was high at Amistad NRA (AMIS) Upland and Carlsbad Caverns NP (CAVE) Upland, and low at Big Bend NP (BIBE) Upland and White Sands NP (WHSA) Upland (Table 3-50). Among species in these park-habitats, the highest Cassin's Sparrow ranked in probability of occupying a transect was fifth, at Amistad NRA Upland, and eighth, at Carlsbad Caverns NP Upland.

Density of Cassin's Sparrow was highest at Amistad NRA Upland (0.35 birds/ha [0.28–0.44]), and lowest at Big Bend NP Upland (0.02 birds/ha [0.01–0.05]) and Carlsbad Caverns NP Upland (0.08 birds/ha [0.05–0.12]; Table 3-51). Among species at these park-habitats, Cassin's Sparrow ranked third in density at Amistad NRA Upland and seventh at Carlsbad Caverns NP Upland.

Cassin's Sparrow has a moderate Continental Combined Score (11) and a moderate regional threats score (3) in the Avian Conservation Assessment Database (ACAD; Table

Table 3-51. Average density of Cassin's Sparrow in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
AMIS Upland	0.35 (0.28–0.44)	11	508	3
BIBE Upland	0.02 (0.01–0.05)	46	123	15
CAVE Upland	0.08 (0.05–0.12)	24	169	7

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

Table 3-50. Average occupancy of Cassin's Sparrow, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.92 (0.77–0.99)	6	275	5	0.48 (0.33–0.65)	17	275	9
BIBE Upland	0.33 (0.17–0.57)	31	53	25	0.07 (0.02–0.19)	59	53	22
CAVE Upland	0.78 (0.54–0.95)	14	77	8	0.17 (0.07–0.36)	42	77	15
GUMO Upland	0.49 (0.27–0.80)	26	32	20	0.09 (0.02–0.27)	66	32	21
WHSA Upland	0.25 (0.12–0.48)	35	32	16	0.28 (0.07–0.68)	53	32	6

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

3-52). Its regional population trend score (5 out of 5) indicates high vulnerability (i.e., a significant, large decrease). The relative density score (5) for this species indicates that it breeds in high mean abundance within the region, similar to the region(s) in which it occurs in maximum density. The percentage of its population in Bird Conservation Region (BCR) 35 is 12.5%. Cassin's Sparrow meets the criteria to be considered a regional concern species, but it is not listed under any of the remaining conservation status categories in the table. Because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability in the parks.

Table 3-52. Conservation status of Cassin's Sparrow at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	11
Federally listed under ESA	no
Regional Population Trend (PT-r)	5
Regional Threats-Breeding (TB-r)	3
Relative Density-Breeding (RD-b)	5
Percent of Global Population in BCR (% Pop)	12.5
Regional Concern	yes
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.19 Cave Swallow (*Petrochelidon fulva*)



Cave Swallow. Credit: NPS

Cave Swallow (*Petrochelidon fulva*) is a migratory, gregarious breeding species in all park units of the CHDN, except Guadalupe Mountains NP and White Sands NP (Appendix B). It is a possible breeder in Guadalupe Mountains NP, where it is identified as an occasional species (i.e., seen at least once every few years, but not necessarily every year). We detected this species in all park units except White Sands NP. Cave Swallow nests in human-made or natural cave structures (Billerman et al. 2020).

Transect occupancy of Cave Swallow was high at Carlsbad Caverns NP (CAVE) Upland (Table 3-53), the only park-habitat where occupancy of this species was estimated. Among species at this park-habitat, Cave Swallow did not rank high in probability of occupying a transect.

Carlsbad Caverns NP Upland was also the only park-habitat in which the density of Cave Swallow was estimated; density of this species was 0.34 birds/ha (0.16–0.70; Table 3-54). Among species at this park-habitat, Cave Swallow ranked second in density.

Cave Swallow has a low Continental Combined Score (8), as well as low regional population trend (1) and regional threats (2) scores, in the Avian Conservation Assessment Database (ACAD; Table 3-55). Its relative density score (3) is moderate, meaning that it breeds in moderate average abundance relative to the region(s) in which it occurs in maximum density. The percentage of its population in Bird Conservation Region (BCR) 35 is only 2.2%. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability status in the parks.

Table 3-54. Average density of Cave Swallow in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
CAVE Upland	0.34 (0.16–0.70)	37	229	2

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

Table 3-53. Average occupancy of Cave Swallow, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
CAVE Upland	0.74 (0.48–0.93)	17	47	11	0.26 (0.04–0.74)	62	47	8

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-55. Conservation status of Cave Swallow at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	8
Federally listed under ESA	no
Regional Population Trend (PT-r)	1
Regional Threats-Breeding (TB-r)	2
Relative Density-Breeding (RD-b)	3
Percent of Global Population in BCR (% Pop)	2.2
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.20 Cliff Swallow (*Petrochelidon pyrrhonota*)



Cliff Swallow. Credit: CATHERINE HARRIS, USFWS

Cliff Swallow (*Petrochelidon pyrrhonota*) is a migratory, gregarious breeding species in all park units of the CHDN except White Sands NP (Appendix B). We detected this species in all park units. Cliff Swallows build mud nests underneath bridges or culverts, as well as under natural rock overhangs, and they forage in open areas near water (Billerman et al. 2020).

Transect occupancy of Cliff Swallow was high at Amistad NRA (AMIS) Upland and moderate at Amistad NRA Riparian (Table 3-56). Among species in these park-habitats, Cliff Swallow did not rank high in probability of occupying a transect.

We estimated density in only one park-habitat, Amistad NRA Upland, where density was 1.02 birds/ha (0.45–2.32; Table 3-57). Among species in this park-habitat, Cliff Swallow ranked first in density.

Cliff Swallow has a low Continental Combined Score (6), as well as a low regional threats score (2), in the Avian Conservation Assessment Database (ACAD; Table 3-58). The relative density score is moderate (3), while the regional population trend score is high (5), indicating a significant, large decrease in population within the region. The percentage of its population in Bird Conservation Region (BCR) 35 is small (less than 1%). This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability status in the parks.

Table 3-56. Average occupancy of Cliff Swallow, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.70 (0.48–0.93)	17	84	20	0.42 (0.16–0.86)	41	84	13
AMIS Riparian	0.62 (0.43–0.89)	19	26	13	0.63 (0.21–0.97)	34	26	1
GUMO Upland	0.69 (0.39–0.92)	21	14	11	0.07 (0.01–0.85)	134	14	23

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.
Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-57. Average density of Cliff Swallow in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
AMIS Upland	1.02 (0.45–2.32)	43	313	1

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

Table 3-58. Conservation status of Cliff Swallow at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	6
Federally listed under ESA	no
Regional Population Trend (PT-r)	5
Regional Threats-Breeding (TB-r)	2
Relative Density-Breeding (RD-b)	3
Percent of Global Population in BCR (% Pop)	0.8
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
NM Avian Conservation Partners	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.21 Common Ground Dove (*Columbina passerina*)



Common Ground Dove. Credit: © ROBERT SHANTZ

Common Ground Dove (*Columbina passerina*) is a resident species that breeds in Big Bend NP and Amistad NRA (Appendix B), and we detected this species in both of these parks. We also detected the call of one individual in 2014 at Fort Davis NHS, but the bird may have been vocalizing from just outside the park boundary. Common Ground Dove prefers open, early successional, sandy, shrub habitats during the breeding season (Billerman et al. 2020).

Transect occupancy of Common Ground Dove was high at Amistad NRA (AMIS) Upland and moderate at Big Bend NP (BIBE) Riparian (Table 3-59). Among species at these park-habitats, Common Ground Dove did not rank high among species in probability of occupying a transect.

Based on low detection numbers, we did not estimate density of Common Ground Dove for any park-habitat combination.

Common Ground Dove has a moderate Continental Combined Score (9) in the Avian Conservation Assessment Database (ACAD; Table 3-60). It has a relatively low regional population trend score (2) and a moderate (3 out of 5) regional threats score. Its relative density score (2) is low, meaning that it breeds in low mean abundance relative to the region(s) in which it occurs in maximum density. The percent of its population in Bird Conservation Region (BCR) 35 is also very low (0.1%). Common Ground Dove is an endangered species in New Mexico; however, we did not include it as a species of conservation concern (see Section 3.1), because it is not known to breed in the CHDN parks in New Mexico (although it breeds in Amistad NRA and Big Bend NP in Texas). We therefore did not assess its breeding habitat availability in the parks.

Table 3-59. Average occupancy of Common Ground Dove, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.73 (0.44–0.92)	17	22	18	0.39 (0.06–1.00)	58	22	15
BIBE Riparian	0.61 (0.42–0.85)	18	42	15	0.25 (0.12–0.66)	47	42	27

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-60. Conservation status of Common Ground Dove at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	9
Federally listed under ESA	no
Regional Population Trend (PT-r)	2
Regional Threats-Breeding (TB-r)	3
Relative Density-Breeding (RD-b)	2
Percent of Global Population in BCR (% Pop)	0.1
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	E
NM Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.22 Common Yellowthroat (*Geothlypis trichas*)



Common Yellowthroat. Credit: TOM KOERNER, USFWS

Common Yellowthroat (*Geothlypis trichas*) is a migratory species that breeds in Amistad NRA, Big Bend NP, and Carlsbad Caverns NP (Appendix B). We detected this species in all park units except Fort Davis NHS and White Sands NP. Common Yellowthroat prefers dense riparian and wetland vegetation, often along shorelines, during the breeding season (Benson and Arnold 2001).

Transect occupancy of Common Yellowthroat was high in Big Bend NP (BIBE) Riparian and moderate in Amistad NRA (AMIS) Riparian (Table 3-61). Among species in these park-habitats, the highest Common Yellowthroat ranked in probability of occupying a transect was at Big Bend NP Riparian (eighth). Unconditional point occupancy at Carlsbad Caverns NP (CAVE) Riparian was high; however, Common Yellowthroat did not rank high among species in probability of occupying a point at this park-habitat.

Density of Common Yellowthroat was estimated only at Big Bend NP Riparian (0.24 birds/ha [0.17–0.34]; Table 3-62). Among species in this park-habitat, Common Yellowthroat ranked fifth in density.

Common Yellowthroat has a moderate Continental Combined Score (9) and a low relative density score (2) in the Avian Conservation Assessment Database (ACAD; Table 3-63). Its regional population trend and regional threats scores are both moderate (3 out of 5). The regional threats score indicates moderate vulnerability. The percentage of its population in Bird Conservation Region (BCR) 35 is a low 0.2%. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability status in the parks.

Table 3-62. Average density of Common Yellowthroat in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
BIBE Riparian	0.24 (0.17–0.34)	18	173	5

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

Table 3-61. Average occupancy of Common Yellowthroat, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Riparian	0.49 (0.26–0.74)	25	31	27	0.29 (0.14–0.54)	33	31	24
BIBE Riparian	0.77 (0.58–0.91)	11	130	8	0.42 (0.31–0.52)	13	130	15
CAVE Riparian	–	–	–	–	0.71 (0.49–0.92)	16	39	15

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-63. Conservation status of Common Yellowthroat at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	9
Federally listed under ESA	no
Regional Population Trend (PT-r)	3
Regional Threats-Breeding (TB-r)	3
Relative Density-Breeding (RD-b)	2
Percent of Global Population in BCR (% Pop)	0.2
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
NM Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.23 Curve-billed Thrasher (*Toxostoma curvirostre*)



Curve-billed Thrasher. Credit: © ROBERT SHANTZ

Curve-billed Thrasher (*Toxostoma curvirostre*) is a resident species that breeds in all CHDN park units (Appendix B), and we detected this species in all park units. Curve-billed Thrasher is a common desert species that often forages on the ground or in low shrubs, preferring semi-open breeding habitats with thorny scrub that contains cactus and yucca (Benson and Arnold 2001).

Transect occupancy of Curve-billed Thrasher was high in Big Bend NP (BIBE) Upland (Table 3-64). We did not categorize Curve-billed Thrasher occupancy (high, moderate, low) in other park-habitat combinations because of very low precision in the estimates (i.e., credible interval range >0.50). Among species in Big Bend NP Upland, Curve-billed Thrasher ranked tenth in probability of occupying a transect.

Density of Curve-billed Thrasher was estimated only at Big Bend NP Upland, where it was 0.02 birds/ha (0.01–0.03; Table 3-65). Among species detected at this park-habitat, Curve-billed Thrasher did not rank high in density.

Curve-billed Thrasher has a moderate Continental Combined Score (9) and a low regional threats score (2) in the Avian Conservation Assessment Database (ACAD; Table 3-66). Its regional population trend score (3) indicates moderate vulnerability. The relative density score (4) for this species indicates that it breeds in moderately high mean abundance relative to the region(s) in which it occurs in maximum density, while the percentage of its population in Bird Conservation Region (BCR) 35 is 6.2%. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in

Table 3-65. Average density of Curve-billed Thrasher in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
BIBE Upland	0.02 (0.01–0.03)	16	138	16

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

Table 3-64. Average occupancy of Curve-billed Thrasher, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.51 (0.25–0.80)	28	29	29	0.13 (0.04–0.33)	53	29	30
BIBE Upland	0.71 (0.51–0.90)	15	89	10	0.09 (0.04–0.18)	38	89	20
CAVE Upland	0.51 (0.23–0.84)	31	13	16	0.06 (0.02–0.18)	61	13	20
GUMO Upland	0.66 (0.31–0.94)	27	19	14	0.05 (0.02–0.13)	50	19	25

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Section 2.4, we did not assess its breeding habitat availability status in the parks.

Table 3-66. Conservation status of Curve-billed Thrasher at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	9
Federally listed under ESA	no
Regional Population Trend (PT-r)	3
Regional Threats-Breeding (TB-r)	2
Relative Density-Breeding (RD-b)	4
Percent of Global Population in BCR (% Pop)	6.2
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
NM Avian Conservation Partners	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.24 Eurasian Collared-Dove (*Streptopelia decaocto*)



Eurasian Collared-Dove. Credit: © ROBERT SHANTZ

Eurasian Collared-Dove (*Streptopelia decaocto*) is an introduced, non-native, resident species that originates from Asia. It breeds in all CHDN park units (Appendix B), and we detected this species in all park units except White Sands NP (where it is considered rare). Eurasian Collared-Dove prefers habitats that are slightly developed and open, and that contain scattered trees for nesting and roosting (Billerman et al. 2020).

Although we estimated transect and unconditional point occupancy for Eurasian Collared-Dove, we did not categorize occupancy (high, moderate, or low) because of very low precision in the estimates (i.e., credible interval range >0.50; Table 3-67).

Based on low detection numbers, we did not estimate density of this species for any park-habitat combinations.

Eurasian Collared-Dove has a low Continental Combined Score (4, the lowest score possible) in the Avian Conservation Assessment Database (ACAD; Table 3-68). This species also has low regional population trend (1) and regional threats (1) scores, both of which indicate low vulnerability. The regional population trend score of 1 indicates a significant, large population increase. The relative density score is comparatively high (4 out of 5), indicating that the species breeds in moderately high mean abundance relative to the region(s) in which it occurs in maximum density; however, the percentage of its population in Bird Conservation Region (BCR) 35 is less than 1.0%. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability status in the parks.

Table 3-67. Average occupancy of Eurasian collared-Dove, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.49 (0.22–0.84)	31	11	30	0.64 (0.09–1.00)	41	11	6
BIBE Riparian	0.42 (0.19–0.75)	33	20	27	0.44 (0.07–0.92)	51	20	14
FODA Upland	–	–	–	–	0.53 (0.11–0.92)	41	11	8

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-68. Conservation status of Eurasian Collared-Dove at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	4
Federally listed under ESA	no
Regional Population Trend (PT-r)	1
Regional Threats-Breeding (TB-r)	1
Relative Density-Breeding (RD-b)	4
Percent of Global Population in BCR (% Pop)	0.2
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.25 Greater Roadrunner (*Geococcyx californianus*)



Greater Roadrunner. Credit: NPS / JOHN MULLER

Greater Roadrunner (*Geococcyx californianus*) is a resident species that breeds in all park units of the CHDN (Appendix B), and we detected it in all park units. In the Chihuahuan Desert, Greater Roadrunner prefers desert scrub, open brushland and woodland, and savanna habitats (Benson and Arnold 2001).

Transect occupancy of Greater Roadrunner was high in Big Bend NP (BIBE) Upland (Table 3-69). Among species in this park-habitat, Greater Roadrunner did not rank high among species in probability of occupying a transect.

Greater Roadrunner density was estimated only in Big Bend NP Upland, where there were 0.01 birds/ha (0.01–0.02; Table 3-70). Among species detected at this park-habitat, Greater Roadrunner did not rank high in density.

Greater Roadrunner has a low Continental Combined Score in the Avian Conservation Assessment Database (ACAD; 8), as well as a low regional threats score (2; Table 3-71). Its regional population trend score (2) indicates a population increase. The relative density score (4) means that Greater Roadrunner breeds in moderately high mean abundance relative to the region(s) in which it occurs in maximum density. Twelve percent of its global population occurs in Bird Conservation Region (BCR) 35. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability status in the parks.

Table 3-70. Average density of Greater Roadrunner in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
BIBE Upland	0.01 (0.01–0.02)	23	151	18

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park habitat.

Table 3-69. Average occupancy of Greater Roadrunner, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
BIBE Upland	0.71 (0.49–0.92)	16	73	11	0.21 (0.05–0.49)	51	73	14
BIBE Riparian	0.57 (0.33–0.88)	24	20	22	0.59 (0.14–0.97)	39	20	5
GUMO Upland	0.57 (0.31–0.90)	26	16	15	0.21 (0.03–0.61)	65	16	10

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-71. Conservation status of Greater Roadrunner at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score	8
Federally listed under ESA	no
Regional Population Trend (PT-r)	2
Regional Threats-Breeding (TB-r)	2
Relative Density-Breeding (RD-b)	4
Percent of Global Population in Bird Conservation Region (BCR; % Pop)	12
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.26 Great-tailed Grackle (*Quiscalus mexicanus*)



Great-tailed Grackle. Credit: JOHN AND KAREN HOLLINGSWORTH, USFWS

Great-tailed Grackle (*Quiscalus mexicanus*) is a resident species that breeds in Amistad NRA, Carlsbad Caverns NP, Fort Davis NHS, and White Sands NP, and is a possible breeder in Big Bend NP and Guadalupe Mountains NP (Appendix B). We detected Great-tailed Grackle in all park units except White Sands NP. Great-tailed Grackle prefers disturbed, developed, and other open habitats where water sources and scattered trees are available, as well as developed urban areas (Billerman et al. 2020).

Although transect occupancy of Great-tailed Grackle was estimated in two park-habitats, we did not categorize occupancy (high, moderate, or low) because of very low precision in the estimates (i.e., credible interval range >0.50; Table 3-72).

Based on low detection numbers, we did not estimate density of Great-tailed Grackle for any park-habitat combinations.

Great-tailed Grackle has a low Continental Combined Score (5) in the Avian Conservation Assessment Database (ACAD; Table 3-73), one point above the lowest score possible. This species also has low scores for regional population trend (1), regional threats (1), and relative density (2), with the first two scores indicating low vulnerability. Only a small percentage (0.6%) of the global Great-tailed Grackle population occurs in Bird Conservation Region (BCR) 35. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability status in the parks.

Table 3-72. Average occupancy of Great-tailed Grackle, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.67 (0.36–0.93)	24	44	23	0.38 (0.08–0.98)	55	44	16
AMIS Riparian	0.61 (0.32–0.90)	25	12	14	0.57 (0.09–0.96)	44	12	3

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.
Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-73. Conservation status of Great-tailed Grackle at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	5
Federally listed under ESA	no
Regional Population Trend (PT-r)	1
Regional Threats-Breeding (TB-r)	1
Relative Density-Breeding (RD-b)	2
Percent of Global Population in BCR (% Pop)	0.6
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.27 Horned Lark (*Eremophila alpestris*)



Horned Lark. Credit: © ROBERT SHANTZ

Horned Lark (*Eremophila alpestris*) is a resident species that breeds in Amistad NRA and White Sands NP, and is a possible breeder in Carlsbad Caverns NP (Appendix B). We detected Horned Lark in Big Bend NP, Guadalupe Mountains NP, and White Sands NP. Horned Lark prefers open habitats with bare ground or short grasses (Billerman et al. 2020).

Occupancy and density estimates for Horned Lark are available only in White Sands NP (WHSA) Upland. However, we did not categorize transect occupancy for Horned Lark in this park-habitat because of the very low precision in the estimate (i.e., credible interval range >0.50; Table 3-74).

Density of Horned Lark in White Sands NP Upland was 0.05 birds/ha (0.03–0.09; Table 3-75). Among species in this park-habitat, Horned Lark ranked third in density.

Horned Lark has a moderate Continental Combined Score (9) in the Avian Conservation Assessment Database (ACAD; Table 3-76), as well as relatively low regional threats (2) and relative density (2) scores. The regional population trend score is high (5 out of 5), indicating a significant, large decrease in population size within the region. Only 0.3% of the global Horned Lark population occurs in Bird Conservation Region (BCR) 35. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability status in the parks.

Table 3-75. Estimated density of Horned Lark in CHDN parks and habitats.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
WHSA Upland	0.05 (0.03–0.09)	32	114	3

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

Table 3-74. Average occupancy of Horned Lark, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
WHSA Upland	0.54 (0.30–0.85)	26	72	8	0.16 (0.02–0.44)	63	72	13

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-76. Conservation status of Horned Lark at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	9
Federally listed under ESA	no
Regional Population Trend (PT-r)	5
Regional Threats-Breeding (TB-r)	2
Relative Density-Breeding (RD-b)	2
Percent of Global Population in BCR (% Pop)	0.3
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.28 House Finch (*Haemorhous mexicanus*)



House Finch. Credit: © ROBERT SHANTZ

House Finch (*Haemorhous mexicanus*) is a common resident species breeding in all CHDN park units (Appendix B), and we detected House Finch in all park units. This species is common throughout much of the United States and tends to avoid dense forests, preferring open desert grassland/shrubland, open woodland, and slightly developed areas in association with humans (Billerman et al. 2020).

Transect occupancy of House Finch was high at Amistad NRA (AMIS) Upland, Big Bend NP (BIBE) Upland and Riparian, Carlsbad Caverns NP (CAVE) Upland, and Guadalupe Mountains NP (GUMO) Upland (Table 3-77). Transect occupancy was moderate at White Sands NP (WHSA) Upland. Among species in these park-habitats, the highest House Finch ranked in probability of occupying a transect was at Carlsbad Caverns NP Upland (fifth). The species ranked sixth at Big Bend NP Upland, Guadalupe Mountains NP Upland, and White Sands NP Upland.

Unconditional point occupancy was high at Carlsbad Caverns NP Riparian, and low at Fort Davis NHS (FODA) Upland and Guadalupe Mountains NP Riparian. House Finch ranked second in probability of point occupancy among species at Carlsbad Caverns NP Riparian.

Table 3-77. Average occupancy of House Finch, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.76 (0.53–0.93)	14	48	15	0.28 (0.15–0.59)	37	48	21
AMIS Riparian	0.56 (0.30–0.84)	25	27	21	0.40 (0.11–0.85)	46	27	15
BIBE Upland	0.88 (0.76–0.97)	6	262	6	0.30 (0.19–0.54)	28	262	7
BIBE Riparian	0.73 (0.53–0.94)	15	58	10	0.34 (0.12–0.76)	45	58	21
CAVE Upland	0.83 (0.63–0.97)	11	58	5	0.31 (0.17–0.64)	35	58	3
CAVE Riparian	–	–	–	–	0.95 (0.80–1.00)	6	45	2
FODA Upland	–	–	–	–	0.26 (0.10–0.57)	42	33	16
GUMO Upland	0.78 (0.57–0.94)	12	59	6	0.25 (0.12–0.54)	39	59	6
GUMO Riparian	–	–	–	–	0.23 (0.12–0.46)	36	12	25
WHSA Upland	0.56 (0.35–0.79)	20	38	6	0.27 (0.12–0.57)	39	38	7

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Density of House Finch was estimated only at Big Bend NP Upland, where it was 0.09 birds/ha (0.07–0.12; Table 3-78). Among species detected at this park-habitat, House Finch ranked fifth in estimated density.

House Finch has a low Continental Combined Score (6), as well as low regional population trend (2) and regional threats (1) scores in the Avian Conservation Assessment Database (ACAD; Table 3-79). The relative density score is comparatively high (4 out of 5), indicating the species breeds in moderately high mean abundance relative to the region(s) in which it occurs in maximum density. The percentage of its population in Bird Conservation Region (BCR) 35 is 5.1%. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability in the parks.

Table 3-78. Average density of House Finch in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
BIBE Upland	0.09 (0.07–0.12)	14	367	5

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

Table 3-79. Conservation status of House Finch at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	6
Federally listed under ESA	no
Regional Population Trend (PT-r)	2
Regional Threats-Breeding (TB-r)	1
Relative Density-Breeding (RD-b)	4
Percent of Global Population in BCR (% Pop)	5.1
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.29 Ladder-backed Woodpecker (*Dryobates scalaris*)



Ladder-backed Woodpecker. Credit: © ROBERT SHANTZ

Ladder-backed Woodpecker (*Dryobates scalaris*) is a resident species that breeds in all CHDN park units (Appendix B), and we detected it in all CHDN park units. This nonmigratory species of the southwestern United States prefers desert scrub, deciduous tree stands, and riparian habitat (Benson and Arnold 2001).

Transect occupancy of Ladder-backed Woodpecker was high at Big Bend NP (BIBE) Riparian (Table 3-80). Among species in this park-habitat, Ladder-backed Woodpecker ranked seventh in probability of occupying a transect. Unconditional point occupancy was high at Carlsbad Caverns NP (CAVE) Riparian, but among species in this park-habitat, it did not rank high in probability of occupying a point.

Based on low detection numbers, we did not estimate density of Ladder-backed Woodpecker for any park-habitat combinations.

Ladder-backed Woodpecker has a moderate Continental Combined Score (9) in the Avian Conservation Assessment Database (ACAD; Table 3-81), as well as low regional population trend (2) and regional threats (2) scores. The relative density score is comparatively high (4), indicating that the species breeds in moderately high mean abundance relative to the region(s) in which the species occurs in maximum density. The percentage of its global population in Bird Conservation Region (BCR) 35 is 6.2%. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability in the parks.

Table 3-80. Average occupancy of Ladder-backed Woodpecker, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.69 (0.35–0.92)	22	11	21	0.83 (0.24–1.00)	28	11	1
BIBE Upland	0.48 (0.24–0.78)	28	18	20	0.65 (0.04–1.00)	42	18	4
BIBE Riparian	0.78 (0.56–0.96)	14	30	7	0.42 (0.18–0.87)	40	30	16
CAVE Riparian	–	–	–	–	0.84 (0.53–0.99)	16	21	8
FODA Upland	–	–	–	–	0.65 (0.20–0.94)	32	12	4
GUMO Riparian	–	–	–	–	0.57 (0.30–0.94)	29	18	19

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-81. Conservation status of Ladder-backed Woodpecker at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	9
Federally listed under ESA	no
Regional Population Trend (PT-r)	2
Regional Threats-Breeding (TB-r)	2
Relative Density-Breeding (RD-b)	4
Percent of Global Population in BCR (% Pop)	6.2
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.30 Lesser Goldfinch (*Spinus psaltria*)



Lesser Goldfinch. Credit: ROBERT BURTON, USFWS

Lesser Goldfinch (*Spinus psaltria*) is a resident species that breeds in all CHDN park units except White Sands NP, where it is a possible breeder (Appendix B). We detected Lesser Goldfinch in all CHDN park units. During the breeding season, this species is found in habitats where desirable seeds from annual plants are available, in woodlands, and on slopes containing juniper and oak (Benson and Arnold 2001).

Although transect occupancy of Lesser Goldfinch was estimated at one park-habitat in the CHDN, and unconditional point occupancy was estimated at two park-habitats, we did not categorize occupancy (high, moderate, or low) because of very low precision in the estimates (i.e., credible interval range >0.50; Table 3-82).

We did not estimate density of Lesser Goldfinch for any park-habitat due to low detection numbers.

Lesser Goldfinch has a low Continental Combined Score (7) in the Avian Conservation Assessment Database (ACAD), as well as low regional population trend (2), regional threats (2), and relative density (2) scores (Table 3-83). The first two of these three scores indicate low vulnerability. The percent of Lesser Goldfinch's global population in Bird Conservation Region (BCR) 35 is 1.1%. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability in the parks.

Table 3-82. Average occupancy of Lesser Goldfinch, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
BIBE Riparian	0.52 (0.27–0.84)	27	13	24	0.34 (0.08–0.78)	50	13	22
CAVE Riparian	–	–	–	–	0.61 (0.33–0.92)	25	16	19
FODA Upland	–	–	–	–	0.64 (0.18–0.94)	33	15	5

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-83. Conservation status of Lesser Goldfinch at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	7
Federally listed under ESA	no
Regional Population Trend (PT-r)	2
Regional Threats-Breeding (TB-r)	2
Relative Density-Breeding (RD-b)	2
Percent of Global Population in BCR (% Pop)	1.1
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.31 Loggerhead Shrike (*Lanius ludovicianus*)



Loggerhead Shrike. Credit: DAVE MENKE, USFWS

Loggerhead Shrike (*Lanius ludovicianus*) is a resident species breeding in all CHDN park units (Appendix B). We detected Loggerhead Shrike in all CHDN park units except Fort Davis NHS. Impaling its prey on barbed fences and thorns, this species has earned the name, "butcherbird." In the breeding season it nests in areas that are open, have low vegetation, and consist of widely spaced, thorny shrubs and trees (Benson and Arnold 2001).

Transect occupancy of Loggerhead Shrike was moderate at Big Bend NP (BIBE) Upland (Table 3-84). We did not categorize occupancy (high, moderate, low) at other park-habitat combinations because of very low precision in the estimates (i.e., credible interval range >0.50). Among species at Big Bend NP Upland, Loggerhead Shrike did not rank high among species in probability of occupying a transect.

Density of Loggerhead Shrike was estimated only at Big Bend NP Upland, where it was 0.01 birds/ha (0.01–0.02; Table 3-85). Among species detected at this park-habitat, Loggerhead Shrike did not rank high in estimated density.

Loggerhead Shrike has a moderate Continental Combined Score (11), and a moderate regional threats score (3), in the Avian Conservation Assessment Database (ACAD; Table 3-86). Its regional population trend score is high (5 out of 5), indicating a significant, large decrease in population size within the region. The relative density score is comparatively high (4 out of 5), indicating the species breeds in moderately high mean abundance relative to the region(s) in which it occurs in maximum density. The percentage of its population in Bird Conservation Region (BCR) 35 is 4.7%. Loggerhead Shrike is considered a regional concern species. Also, Loggerhead Shrike has a G4 ("apparently secure") ranking with NatureServe. As this species does not meet any criteria for a species of conser-

Table 3-85. Average density of Loggerhead Shrike in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
BIBE Upland	0.01 (0.01–0.02)	22	128	17

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

Table 3-84. Average occupancy of Loggerhead Shrike, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
BIBE Upland	0.54 (0.35–0.77)	20	73	18	0.78 (0.18–1.00)	29	73	1
GUMO Upland	0.66 (0.40–0.93)	21	33	13	0.86 (0.19–1.00)	28	33	1
WHSA Upland	0.48 (0.24–0.84)	31	10	10	0.55 (0.03–1.00)	56	10	3

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

vation concern that we used in Section 2.4, we did not assess its breeding habitat availability in the parks.

Table 3-86. Conservation status of Loggerhead Shrike at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G4
Continental Combined Score (CCS-max)	11
Federally listed under ESA	no
Regional Population Trend (PT-r)	5
Regional Threats-Breeding (TB-r)	3
Relative Density-Breeding (RD-b)	4
Percent of Global Population in BCR (% Pop)	4.7
Regional Concern	yes
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
NM Avian Conservation Partners	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.32 Lucy's Warbler (*Leiothlypis luciae*)



Lucy's Warbler. Credit: © ROBERT SHANTZ

Lucy's Warbler (*Leiothlypis luciae*) is a short-distance migratory species breeding in Big Bend NP and Carlsbad Caverns NP (Appendix B). We detected Lucy's Warbler in Amistad NRA, Big Bend NP, and Carlsbad Caverns NP. Lucy's Warbler breeds in riparian habitat, often within old mesquite groves, and can be found nesting along the Rio Grande in west Texas and at Rattlesnake Spring in Carlsbad Caverns NP (Benson and Arnold 2001). Lucy's Warbler is the only cavity-nesting warbler in the western United States, and one of only two in North America (Billerman et al. 2020). Mature riparian habitat is preferred for nesting, but this species will use marginal habitat in its absence (Benson and Arnold 2001).

Although transect occupancy of Lucy's Warbler was estimated at one park-habitat in the CHDN, and unconditional point occupancy was estimated at another park-habitat, we did not categorize occupancy (high, moderate, or low) because of very low precision in the estimates (i.e., credible interval range >0.50; Table 3-87).

Based on low detection numbers, we did not estimate density of Lucy's Warbler for any park-habitat.

Lucy's Warbler has a moderate Continental Combined Score (11), and moderate regional population trend (3) and relative density (3) scores, in the Avian Conservation Assessment Database (ACAD; Table 3-88). Its regional threats-breeding score, a 4 out of 5, indicates relatively high vulnerability. The percent of Lucy's Warbler's global population occurring in Bird Conservation Region (BCR) 35 is 9.8%. This species is of regional concern (see Table 3-88). However, because this species does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability in the parks.

Table 3-87. Average occupancy of Lucy's Warbler, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
BIBE Riparian	0.53 (0.32–0.86)	25	30	23	0.27 (0.06–0.63)	52	30	25
CAVE Riparian	–	–	–	–	0.71 (0.38–0.98)	24	12	16

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-88. Conservation status of Lucy's Warbler at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	11
Federally listed under ESA	no
Regional Population Trend (PT-r)	3
Regional Threats-Breeding (TB-r)	4
Relative Density-Breeding (RD-b)	3
Percent of Global Population in BCR (% Pop)	9.8
Regional Concern	yes
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.33 Mourning Dove (*Zenaida macroura*)



Mourning Dove. Credit: JIM HUDGINS, USFWS

Mourning Dove (*Zenaida macroura*) is a resident species that breeds in all CHDN park units (Appendix B), and we detected it in all CHDN park units. Mourning Dove breeding habitat is ecologically diverse, as is its nesting substrate; however, it generally prefers open habitats with scattered bushes and trees, or countryside with some human development (Benson and Arnold 2001).

Transect occupancy of Mourning Dove was high at Amistad NRA (AMIS) Upland and Riparian, Big Bend NP (BIBE) Upland and Riparian, Carlsbad Caverns NP (CAVE) Upland, and Guadalupe Mountains NP (GUMO) Upland (Table 3-89). Among species in these park-habitats, the highest Mourning Dove ranked in probability of occupying a transect was fourth, at Carlsbad Caverns NP Upland and Guadalupe Mountains NP Upland. It also ranked fifth, sixth, and seventh at three park-habitats.

Unconditional point occupancy was low at Fort Davis NHS (FODA) Upland. Among species at this park-habitat, Mourning Dove did not rank high in probability of occupying a point.

Density of Mourning Dove was estimated at several park-habitats in the CHDN. Density of this species was highest at Big Bend NP Riparian (0.23 birds/ha [0.17–0.31), followed by Amistad NRA Upland (0.13 birds/ha [0.06–0.27]; Table 3-90). Density was less than 0.10 birds/ha at the remaining four park-habitats where it was estimated. Among species in these park-habitats, the highest Mourning Dove ranked in density was fourth (at Guadalupe Mountains NP Upland).

Mourning Dove has a low Continental Combined Score (6, two points above the lowest possible score), and a low regional threats score (2), in the Avian Conservation Assessment Database (ACAD; Table 3-91). Both its

Table 3-89. Average occupancy of Mourning Dove, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.82 (0.61–0.96)	12	73	12	0.24 (0.14–0.41)	29	73	26
AMIS Riparian	0.71 (0.51–0.92)	15	42	6	0.28 (0.11–0.54)	38	42	25
BIBE Upland	0.85 (0.71–0.95)	8	282	7	0.21 (0.14–0.31)	20	282	13
BIBE Riparian	0.87 (0.70–0.96)	8	132	5	0.50 (0.33–0.71)	19	132	9
CAVE Upland	0.83 (0.64–0.97)	11	91	4	0.22 (0.13–0.37)	27	91	10
CAVE Riparian	–	–	–	–	0.52 (0.32–0.95)	29	25	24
FODA Upland	–	–	–	–	0.19 (0.07–0.39)	40	34	20
GUMO Upland	0.81 (0.60–0.97)	12	74	4	0.19 (0.11–0.33)	29	74	12
WHSA Upland	0.61 (0.36–0.87)	22	35	4	0.16 (0.05–0.30)	39	35	12

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-90. Average density of Mourning Dove in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
AMIS Upland	0.13 (0.06–0.27)	40	147	12
BIBE Upland	0.06 (0.05–0.07)	11	661	8
BIBE Riparian	0.23 (0.17–0.31)	15	254	6
CAVE Upland	0.09 (0.05–0.15)	26	182	6
GUMO Upland	0.05 (0.03–0.07)	18	190	4
WHSA Upland	0.02 (0.01–0.03)	32	124	6

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

regional population trend and relative density scores are comparatively high (both 4 out of 5). For the population trend score, this means that there has been a decrease in population size within the region. For relative density, this indicates that Mourning Dove breeds in moderately high mean abundance relative to the region(s) in which it occurs in maximum density. The percentage of its population in Bird Conservation Region (BCR) 35, however, is fairly low (2.3%). This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability in the parks.

Table 3-91. Conservation status of Mourning Dove at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	6
Federally listed under ESA	no
Regional Population Trend (PT-r)	4
Regional Threats-Breeding (TB-r)	2
Relative Density-Breeding (RD-b)	4
Percent of Global Population in BCR (% Pop)	2.3
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.34 Northern Cardinal (*Cardinalis cardinalis*)



Northern Cardinal. Credit: MARVINANN PATTERSON, USFWS

Northern Cardinal (*Cardinalis cardinalis*) is a resident species that breeds in Amistad NRA, Big Bend NP, Carlsbad Caverns NP, and Fort Davis NHS (Appendix B). We detected this species in all CHDN park units. Unlike in the humid eastern United States, where Northern Cardinal is more common and uses diverse upland habitats where bushes and trees are available, in the Southwest, Northern Cardinal is restricted to riparian habitats or human developments (Benson and Arnold 2001).

Occupancy of Northern Cardinal was high in most park-habitats in the CHDN for which we have estimates. Transect occupancy was high at Amistad NRA (AMIS) Upland, Big Bend NP (BIBE) Riparian, and Amistad NRA Riparian (Table 3-92). Among species in these park-habitats, Northern Cardinal ranked near the highest of all species in probability of occupying a transect. It ranked third at Big Bend NP Riparian, fourth at Amistad NRA Upland, and fifth at Amistad NRA Riparian. Unconditional point occupancy was high at Carlsbad Caverns NP (CAVE) Riparian, but Northern Cardinal did not rank high overall among species in this park-habitat.

Density of Northern Cardinal was highest at Amistad NRA Riparian (0.47 birds/ha [0.30–0.72]), followed by Big Bend NP Riparian (0.28 birds/ha [0.21–0.36]), and Amistad NRA Upland (0.13 birds/ha [0.10–0.18]; Table 3-93). Among species in Amistad NRA Riparian and Big Bend NP Riparian, Northern Cardinal ranked third in density in both.

Northern Cardinal has a low Continental Combined Score (5, one point above the lowest possible score), and a low regional population trend score (1 out of 5), in the Avian Conservation Assessment Database (ACAD; Table 3-94). The score for regional population trend indicates a significant, large increase. Its regional threats score is also comparatively low (2). Its relative density score (2) indicates that the species breeds in low mean abundance relative to the region(s)

Table 3-92. Estimated occupancy (averaged across years) of Northern Cardinal, by transect and point, in CHDN parks and habitats.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.92 (0.78–0.99)	6	175	4	0.35 (0.23–0.50)	19	175	17
AMIS Riparian	0.78 (0.60–0.93)	11	93	5	0.51 (0.33–0.70)	18	93	6
BIBE Upland	0.55 (0.22–0.90)	33	11	17	0.01 (0–0.09)	124	11	25
BIBE Riparian	0.90 (0.76–0.98)	6	180	3	0.52 (0.40–0.63)	12	180	8
CAVE Riparian	–	–	–	–	0.82 (0.52–0.98)	15	35	10

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

in which the species occurs in maximum density, and the percentage of its population in Bird Conservation Region (BCR) 35 is a low 0.5%. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability in the parks.

Table 3-93. Average density of Northern Cardinal in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
AMIS Upland	0.13 (0.10–0.18)	14	283	11
AMIS Riparian	0.47 (0.30–0.72)	22	167	3
BIBE Riparian	0.28 (0.21–0.36)	13	344	3

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

Table 3-94. Conservation status of Northern Cardinal at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	5
Federally listed under ESA	no
Regional Population Trend (PT-r)	1
Regional Threats-Breeding (TB-r)	2
Relative Density-Breeding (RD-b)	2
Percent of Global Population in BCR (% Pop)	0.5
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.35 Northern Mockingbird (*Mimus polyglottos*)



Northern Mockingbird. Credit: JESUS MORENO, USFWS

Northern Mockingbird (*Mimus polyglottos*) is a resident species breeding in all CHDN park units (Appendix B), and we detected this species in all CHDN park units. In the western United States, Northern Mockingbird breeds in upland habitats with desert scrub and sparse vegetation, and in Texas, the species has been found in higher numbers in native versus invasive grasslands (Billerman et al. 2020).

Transect occupancy of Northern Mockingbird was high at five park-habitats (Amistad NRA [AMIS] Upland, Big Bend NP [BIBE] Upland, Carlsbad Caverns NP [CAVE] Upland, Guadalupe Mountains NP [GUMO] Upland, and White Sands NP [WHSA] Upland), and moderate at two park-habitats (Amistad NRA Riparian and Big Bend NP Riparian; Table 3-95). Among species in these park-habitats, Northern Mockingbird ranked among the highest in probability of occupying a transect at three park-habitats: Amistad NRA Upland (first), Guadalupe Mountains NP Upland (second), and White Sands NP Upland (third).

Unconditional point occupancy was high at Carlsbad Caverns NP Riparian and low at Fort Davis NHS (FODA) Upland. Among species at these park-habitats, Northern Mockingbird did not rank high in probability of occupying a point.

Northern Mockingbird density was estimated at five park-habitats. It was highest at Amistad NRA Upland, where it was 0.28 birds/ha (0.24–0.34), followed by Carlsbad Caverns NP Upland, where it was 0.12 birds/ha (0.09–0.16; Table 3-96). Density was lower at Big Bend NP Upland, Guadalupe Mountains NP Upland, and White Sands NP Upland. Among species at these park-habitats, Northern Mockingbird den-

Table 3-95. Average occupancy of Northern Mockingbird, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.95 (0.81–0.99)	5	325	1	0.61 (0.49–0.72)	10	325	7
AMIS Riparian	0.54 (0.30–0.80)	23	33	22	0.52 (0.19–0.95)	37	33	5
BIBE Upland	0.81 (0.68–0.91)	7	332	8	0.22 (0.17–0.29)	15	332	12
BIBE Riparian	0.60 (0.39–0.89)	21	42	17	0.39 (0.13–0.84)	44	42	18
CAVE Upland	0.77 (0.58–0.92)	11	154	9	0.34 (0.24–0.48)	17	154	2
CAVE Riparian	–	–	–	–	0.76 (0.52–0.96)	15	34	13
FODA Upland	–	–	–	–	0.14 (0.05–0.30)	44	20	21
GUMO Upland	0.84 (0.68–0.95)	8	115	2	0.19 (0.12–0.30)	24	115	11
WHSA Upland	0.71 (0.50–0.88)	14	101	3	0.22 (0.13–0.35)	25	101	10

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-96. Average density of Northern Mockingbird in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
AMIS Upland	0.28 (0.24–0.34)	9	655	4
BIBE Upland	0.06 (0.05–0.07)	11	1,000	8
CAVE Upland	0.12 (0.09–0.16)	15	497	4
GUMO Upland	0.05 (0.03–0.06)	15	401	5
WHSA Upland	0.05 (0.03–0.07)	20	391	4

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

sity ranked fourth at three park units and fifth at one (Amistad NRA Upland, Carlsbad Caverns NP Upland, White Sands NP Upland, and Guadalupe Mountains NP Upland, respectively).

Northern Mockingbird has a low Continental Combined Score (8), and a low regional threats score (2), in the Avian Conservation Assessment Database (ACAD; Table 3-97). Its regional population trend score is a 4 (out of 5), indicating a decrease in population size within the region. The relative density score is high (5 out of 5), indicating the species breeds in high mean abundance, similar to the region(s) in which it occurs in maximum density. The percentage of its population in Bird Conservation Region (BCR) 35 is 7.4%. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability in the parks.

Table 3-97. Conservation status of Northern Mockingbird at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	8
Federally listed under ESA	no
Regional Population Trend (PT-r)	4
Regional Threats-Breeding (TB-r)	2
Relative Density-Breeding (RD-b)	5
Percent of Global Population in BCR (% Pop)	7.4
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.36 Northern Rough-winged Swallow (*Stelgidopteryx serripennis*)



Northern Rough-winged Swallow. Credit: © ROBERT SHANTZ

Northern Rough-winged Swallow (*Stelgidopteryx serripennis*) is a migratory species that breeds in Amistad NRA and Big Bend NP (Appendix B), and although it is largely a migratory species in the United States, many individuals remain in the CHDN during winter, primarily along the Rio Grande River (eBird 2021). We detected this species in all CHDN park units except Fort Davis NHS. Northern Rough-winged Swallow is a solitary or small-colony nester that digs burrows into exposed river or stream banks and lines nests with vegetation (Benson and Arnold 2001).

Occupancy estimates for Northern Rough-winged Swallow were not categorized (high, moderate, or low) because of very low precision in the estimates (i.e., credible interval range >0.50; Table 3-98).

Due to low detection numbers, we did not estimate the density of this species for any park-habitat combinations.

Northern Rough-winged Swallow has a moderate Continental Combined Score (10), and a moderate regional threats score (3), in the Avian Conservation Assessment Database (ACAD; Table 3-99). Its regional population trend (2) and relative density (2) scores are relatively low; the regional population trend indicates an increase in population size within the region. The percentage of Northern Rough-winged Swallow's global population occurring in Bird Conservation Region (BCR) 35 is less than 1.0%. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability in the parks.

Table 3-98. Average occupancy of Northern Rough-winged Swallow, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Riparian	0.64 (0.38–0.89)	21	35	11	0.25 (0.09–0.54)	45	35	30
BIBE Riparian	0.61 (0.36–0.87)	21	30	16	0.23 (0.07–0.69)	59	30	28

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-99. Conservation status of Northern Rough-winged Swallow at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/ rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	10
Federally listed under ESA	no
Regional Population Trend (PT-r)	2
Regional Threats-Breeding (TB-r)	3
Relative Density-Breeding (RD-b)	2
Percent of Global Population in BCR (% Pop)	0.3
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.39 Orchard Oriole (*Icterus spurius*)



Orchard Oriole. Credit: NPS / BLAKE TRESTER

Orchard Oriole (*Icterus spurius*) is a migratory species that breeds in Amistad NRA, Big Bend NP, and Carlsbad Caverns NP, and is a possible breeder at Fort Davis NHS (Appendix B). We detected this species in Amistad NRA, Big Bend NP, and Carlsbad Caverns NP, as well as one individual in Guadalupe Mountains NP. Orchard Oriole shows a preference for nesting in mesquite and other small, scattered trees (Billerman et al. 2020).

Transect-level occupancy was estimated only at Amistad NRA (AMIS). It was moderate at both Amistad NRA Upland and Amistad NRA Riparian (Table 3-100). Among species at these park-habitats, Orchard Oriole did not rank high in probability of occupying a transect. Unconditional point occupancy was estimated at Carlsbad Caverns NP (CAVE) Riparian but not categorized (high, moderate, low) due to very low precision in the estimate (credible interval range >0.50).

Due to low detection numbers, we did not estimate density of this species for any park-habitat combinations.

Orchard Oriole has a moderate Continental Combined Score (10) in the Avian Conservation Assessment Database (ACAD; Table 3-101), as well as low regional population trend (2) and relative density (2) scores. The regional population trend score of 2 indicates an increase in population size within the region. The regional threats score (3) is moderate, indicating moderate vulnerability. The percentage of its global population in Bird Conservation Region (BCR) 35 is less than 1.0%. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability in the parks.

Table 3-100. Average occupancy of Orchard Oriole, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.63 (0.41–0.89)	19	25	26	0.43 (0.05–0.99)	56	25	12
AMIS Riparian	0.63 (0.40–0.90)	20	20	12	0.36 (0.10–0.86)	50	20	19
CAVE Riparian	–	–	–	–	0.64 (0.35–0.96)	25	20	18

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-101. Conservation status of Orchard Oriole at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	10
Federally listed under ESA	no
Regional Population Trend (PT-r)	2
Regional Threats-Breeding (TB-r)	3
Relative Density-Breeding (RD-b)	2
Percent of Global Population in BCR (% Pop)	0.8
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.37 Painted Bunting (*Passerina ciris*)



Painted Bunting. Credit: NPS

Painted Bunting (*Passerina ciris*) is a migratory species breeding in Amistad NRA, Big Bend NP, and Carlsbad Caverns NP, and is a possible breeder in Fort Davis NHS (Appendix B). We detected this species in Amistad NRA, Big Bend NP, and Carlsbad Caverns NP, as well as one individual in Guadalupe Mountains NP. Painted Bunting breeds in moderately spaced trees and brush, along streams, and among annual forbs and grasses (Billerman et al. 2020).

Occupancy of Painted Bunting at the transect level was high at Amistad NRA (AMIS) Upland and Amistad NRA Riparian (Table 3-102). Among species at Amistad NRA Riparian, Painted Bunting ranked second in probability of transect occupancy. Unconditional point occupancy was high at Carlsbad Caverns NP (CAVE) Riparian, but among species at this park-habitat, Painted Bunting did not rank high in probability of occupying a point.

Density of Painted Bunting was estimated only at Amistad NRA Upland, where density was 0.10 birds/ha (0.07–0.14; Table 3-103). Among species detected at this park-habitat, Painted Bunting did not rank high in estimated density.

Painted Bunting has a moderate Continental Combined Score (10), and moderate regional threats (3) and relative density (3) scores, in the Avian Conservation Assessment Database (ACAD; Table 3-104). Its regional population trend score (1) is low and indicates a significant, large increase. The percentage of Painted Bunting's global population occurring in Bird Conservation Region (BCR) 35 is 4.6%. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability in the parks.

Table 3-103. Average density of Painted Bunting in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
AMIS Upland	0.10 (0.07–0.14)	16	163	13

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

Table 3-102. Average occupancy of Painted Bunting, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.82 (0.62–0.97)	12	114	11	0.49 (0.22–0.89)	34	114	8
AMIS Riparian	0.82 (0.59–0.96)	12	49	2	0.55 (0.24–0.84)	28	49	4
BIBE Riparian	0.38 (0.20–0.74)	35	28	29	0.41 (0.14–0.77)	40	28	17
CAVE Riparian	–	–	–	–	0.73 (0.53–0.95)	14	30	14

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-104. Conservation status of Painted Bunting at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	10
Federally listed under ESA	no
Regional Population Trend (PT-r)	1
Regional Threats-Breeding (TB-r)	3
Relative Density-Breeding (RD-b)	3
Percent of Global Population in BCR (% Pop)	4.6
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.38 Pyrrhuloxia (*Cardinalis sinuatus*)



Pyrrhuloxia. Credit: GARY KRAMER, USFWS

Pyrrhuloxia (*Cardinalis sinuatus*) is a resident species that breeds in all CHDN park units (Appendix B), and we detected this species in all CHDN park units. Pyrrhuloxia habitat is drier and contains less dense vegetation than Northern Cardinal, its close relative, and open mesquite grassland or desert scrub is preferred (Billerman et al. 2020).

Transect occupancy of Pyrrhuloxia was either high or moderate at all park-habitats for which we have estimates, although precision was low (i.e., credible interval range >0.50) at Riparian habitats (Table 3-105). It was high at Big Bend NP (BIBE) Upland, Amistad NRA (AMIS) Upland, and Carlsbad Caverns NP (CAVE) Upland, and moderate at Guadalupe Mountains NP (GUMO) Upland. Among species at these park-habitats, the highest Pyrrhuloxia ranked in transect occupancy was fourth (at Big Bend NP Upland).

Density of Pyrrhuloxia was highest at Amistad NRA Upland, where it was 0.22 birds/ha (0.15–0.32; Table 3-106). Density was less than 0.10 birds/ha in the remaining three park-habitats where it was estimated, with the highest of the three being 0.08 birds/ha (0.07–0.10) at Big Bend NP Upland. Among species in these park-habitats, the highest Pyrrhuloxia ranked in density was fifth, at Amistad NRA Upland.

Pyrrhuloxia has a moderate Continental Combined Score (13), and a moderate regional population trend score (3), in the Avian Conservation Assessment Database (ACAD; Table 3-107). Its regional threats score (2) is low and indicates comparatively low vulnerability. Its relative density score is

Table 3-105. Average occupancy of Pyrrhuloxia, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.84 (0.71–0.95)	7	208	10	0.47 (0.34–0.63)	16	208	11
AMIS Riparian	0.51 (0.24–0.85)	30	10	25	0.11 (0.03–0.65)	94	10	31
BIBE Upland	0.88 (0.78–0.96)	5	466	4	0.29 (0.23–0.36)	11	466	8
BIBE Riparian	0.58 (0.33–0.87)	24	26	20	0.12 (0.04–0.29)	51	26	30
CAVE Upland	0.74 (0.51–0.91)	14	79	10	0.21 (0.13–0.33)	25	79	12
GUMO Upland	0.55 (0.36–0.78)	20	48	17	0.15 (0.08–0.27)	33	48	16

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.
Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-106. Average density of Pyrrhuloxia in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
AMIS Upland	0.22 (0.15–0.32)	19	329	5
BIBE Upland	0.08 (0.07–0.10)	8	999	6
CAVE Upland	0.04 (0.03–0.06)	20	128	9
GUMO Upland	0.02 (0.01–0.04)	37	100	7

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

comparatively high (4), indicating the species breeds in moderately high mean abundance relative to the region(s) in which the species occurs in maximum density. The percentage of its global population in Bird Conservation Region (BCR) 35 is also a substantial 21.9%. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability in the parks.

Table 3-107. Conservation status of Pyrrhuloxia at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	13
Federally listed under ESA	no
Regional Population Trend (PT-r)	3
Regional Threats-Breeding (TB-r)	2
Relative Density-Breeding (RD-b)	4
Percent of Global Population in BCR (% Pop)	21.9
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.40 Red-winged Blackbird (*Agelaius phoeniceus*)



Red-winged Blackbird. Credit: JOHN J MOSESSO, USGS

Red-winged Blackbird (*Agelaius phoeniceus*) is a resident species breeding in Amistad NRA, Carlsbad Caverns NP, and Guadalupe Mountains NP (Appendix B). We detected this species in these three parks, as well as Big Bend NP. Red-winged Blackbird breeds in diverse habitats, including human croplands that require flooding, upland sedge (*Carex* spp.) meadows, and fields, and in the CHDN the species is primarily found in wetland marshes and along wooded waterways (Billerman et al. 2020).

Occupancy and density estimates were obtained for only one park-habitat, Amistad NRA (AMIS) Riparian. Transect occupancy of Red-winged Blackbird in this park-habitat was moderate (Table 3-108). Among species in Amistad NRA Riparian, Red-winged Blackbird ranked ninth in probability of occupying a transect. Red-winged Blackbird density in Amistad NRA Riparian was 0.51 birds/ha (0.28–0.95; Table 3-109), and among species in this park-habitat, Red-winged Blackbird ranked second in density.

Red-winged Blackbird has a low Continental Combined Score (8), and a low regional population trend score (1, the lowest possible), in the Avian Conservation Assessment Database (ACAD; Table 3-110). The latter score indicates a significant, large increase in population within the region. Its regional threats score is also low (2). Both the relative density score (2) and the percentage of the Red-winged Blackbird population in Bird Conservation Region (BCR) 35 (0.2%) are low. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability in the parks.

Table 3-109. Average density of Red-winged Blackbird in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
AMIS Riparian	0.51 (0.28–0.95)	32	247	2

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

Table 3-108. Average occupancy of Red-winged Blackbird, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Riparian	0.65 (0.42–0.86)	18	76	9	0.44 (0.26–0.66)	23	76	12

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-110. Conservation status of Red-winged Blackbird at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	8
Federally listed under ESA	no
Regional Population Trend (PT-r)	1
Regional Threats-Breeding (TB-r)	2
Relative Density-Breeding (RD-b)	2
Percent of Global Population in BCR (% Pop)	0.2
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.41 Rock Wren (*Salpinctes obsoletus*)



Rock Wren. Credit: © ROBERT SHANTZ

Rock Wren (*Salpinctes obsoletus*) is a resident species that breeds in all CHDN park units except White Sands NP (Appendix B). While we detected this species in all CHDN park units, we detected only one individual at White Sands NP. Rock Wren typically nests on the ground in crevices in exposed rocky habitats, on talus slopes, or in steep canyon walls (Benson and Arnold 2001).

Transect occupancy of Rock Wren was estimated at five park-habitats in the CHDN, although we did not categorize occupancy (high, moderate, low) at two park-habitats because of very low precision in the estimates (i.e., credible interval >0.50). Transect occupancy was high at Amistad NRA (AMIS) Riparian and Big Bend NP (BIBE) Upland (Table 3-111). It was moderate at Big Bend NP Riparian. Among species at these park-habitats, Rock Wren did not rank high in probability of occupying a transect (the highest being seventh at Amistad NRA Riparian). Although unconditional point occupancy was estimated at Fort Davis NHS (FODA) Upland, we did not categorize it due to very low precision in the estimate.

Density of Rock Wren was estimated in two park-habitats. It was higher in Fort Davis NHS Upland, where there were 0.15 birds/ha (0.12–0.20; Table 3-112). Density was 0.03 birds/ha (0.02–0.04) in Big Bend NP Upland. Among species in Fort Davis NHS Upland, Rock Wren ranked third.

Rock Wren has a moderate Continental Combined Score (11) in the Avian Conservation Assessment Database (ACAD; Table 3-113). Although its regional threats score is relatively low (2), its regional population trend score is 5, the highest score possible. This score, which is an indication of vulnerability, indicates a significant, large decrease in population size within the region. Its relative density score is moderate (3), indicating the species breeds in moderate mean abundance relative to the region(s) in which it occurs in maximum density. The percentage of its global population in Bird Conservation Region (BCR) 35 is only 1.5%. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability in the parks.

Table 3-111. Average occupancy of Rock Wren, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Riparian	0.67 (0.41–0.91)	20	41	7	0.28 (0.09–0.62)	46	41	26
BIBE Upland	0.67 (0.48–0.86)	15	121	13	0.11 (0.06–0.21)	33	121	19
BIBE Riparian	0.36 (0.15–0.65)	34	17	30	0.29 (0.07–0.72)	55	17	24
CAVE Upland	0.38 (0.15–0.68)	36	17	19	0.11 (0.03–0.30)	54	17	16
FODA Upland	–	–	–	–	0.49 (0.20–0.80)	31	76	10
GUMO Upland	0.57 (0.28–0.88)	27	18	16	0.04 (0.01–0.13)	60	18	26

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-112. Average density of Rock Wren in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
BIBE Upland	0.03 (0.02–0.04)	20	273	13
FODA Upland	0.15 (0.12–0.20)	13	137	3

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

Table 3-113. Conservation status of Rock Wren at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	11
Federally listed under ESA	no
Regional Population Trend (PT-r)	5
Regional Threats-Breeding (TB-r)	2
Relative Density-Breeding (RD-b)	3
Percent of Global Population in BCR (% Pop)	1.5
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
NM Avian Conservation Partners	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.42 Rufous-crowned Sparrow (*Aimophila ruficeps*)



Rufous-crowned Sparrow. Credit: © ROBERT SHANTZ

Rufous-crowned Sparrow (*Aimophila ruficeps*) is a resident species breeding in all CHDN park units (Appendix B). We detected this species in all CHDN park units except White Sands NP, where it breeds irregularly. In the Southwest, Rufous-crowned Sparrow breeds on rocky, shrubby hillsides or sotol (*Dasylirion* sp.) grasslands (Billerman et al. 2020).

Transect occupancy of Rufous-crowned Sparrow was high at Amistad NRA (AMIS) Upland and Carlsbad Caverns NP (CAVE) Upland (Table 3-114). It was moderate at Big Bend NP (BIBE) Upland and low at Guadalupe Mountains NP (GUMO) Upland. Among these park-habitats, Rufous-crowned Sparrow ranked highest in probability of occupying a transect at Carlsbad Caverns NP Upland, where it ranked third. Unconditional point occupancy was high at Guadalupe Mountains NP Riparian, and among species at this park-habitat, Rufous-crowned Sparrow ranked sixth in point occupancy.

Density was estimated at four park-habitats and ranged from 0.19 birds/ha (0.13–0.28) at Amistad NRA Upland, down to 0.03 birds/ha (0.02–0.06) at Big Bend NP Upland (Table 3-115). Among species in these park-habitats, Rufous-crowned Sparrow ranked second in density at Fort Davis NHS Upland and third in density Carlsbad Caverns NP Upland.

Rufous-crowned Sparrow has a moderate Continental Combined Score (11) in the Avian Conservation Assessment Database (ACAD; Table 3-116). Although its regional threats score is comparatively low (2), its regional population trend score is 5, the highest score possible. This score, which is an indication of vulnerability, indicates a significant, large decrease in population size within the region. Its relative density score is comparatively high (4), indicating the species breeds in moderately high mean abundance relative to the region(s) in which it occurs in maximum density. The percentage of its global

Table 3-114. Average occupancy of Rufous-crowned Sparrow, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.89 (0.72–0.98)	8	156	8	0.33 (0.22–0.47)	19	156	19
AMIS Riparian	0.49 (0.27–0.78)	25	19	26	0.40 (0.11–0.86)	46	19	14
BIBE Upland	0.49 (0.33–0.67)	18	125	19	0.16 (0.10–0.27)	27	125	17
CAVE Upland	0.84 (0.64–0.96)	10	124	3	0.30 (0.19–0.43)	20	124	4
FODA Upland	–	–	–	–	0.42 (0.16–0.71)	34	68	11
GUMO Upland	0.30 (0.14–0.53)	33	51	25	0.33 (0.17–0.56)	30	51	5
GUMO Riparian	–	–	–	–	0.77 (0.56–0.97)	14	58	6

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

population in Bird Conservation Region (BCR) 35 is 9.8%. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability in the parks.

Table 3-115. Average density of Rufous-crowned Sparrow in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
AMIS Upland	0.19 (0.13–0.28)	19	216	7
BIBE Upland	0.03 (0.02–0.06)	25	184	11
CAVE Upland	0.13 (0.08–0.20)	21	216	3
FODA Upland	0.17 (0.12–0.24)	18	109	2

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

Table 3-116. Conservation status of Rufous-crowned Sparrow at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	11
Federally listed under ESA	no
Regional Population Trend (PT-r)	5
Regional Threats-Breeding (TB-r)	2
Relative Density-Breeding (RD-b)	4
Percent of Global Population in BCR (% Pop)	9.8
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.43 Scott's Oriole (*Icterus parisorum*)



Scott's Oriole. Credit: © ROBERT SHANTZ

Scott's Oriole (*Icterus parisorum*) is a migratory species breeding in all CHDN park units (Appendix B), and we detected this species in all park units. In the breeding season, Scott's Oriole is found on Chihuahuan Desert foothills and elevated hillsides supporting lechuguilla (*Agave lechuguilla*) and yucca (Billerman et al. 2020), where it regularly nests amidst the old leaves hanging from the trunk.

Transect occupancy of Scott's Oriole was high at Guadalupe Mountains NP (GUMO) Upland, and moderate at Big Bend NP (BIBE) Upland, White Sands NP (WHSA) Upland, and Carlsbad Caverns NP (CAVE) Upland (Table 3-117). In these park-habitats, Scott's Oriole ranked highest in probability of occupying a transect at Guadalupe Mountains NP Upland (third). Unconditional point occupancy of Scott's Oriole was high at Guadalupe Mountains NP Riparian and low at Fort Davis NHS (FODA) Upland. Scott's Oriole ranked fifth in probability of occupying a point at Guadalupe Mountains NP Riparian.

Density of Scott's Oriole was low at the three park-habitats where it was estimated. It ranged from 0.06 birds/ha (0.04-0.08) at Guadalupe Mountains NP Upland, down to 0.01 birds/ha (0.01-0.03) at White Sands NP Upland (Table 3-118). The highest it ranked in density among species was third (at Guadalupe Mountains NP Upland).

Scott's Oriole has a moderate Continental Combined Score (13) in the Avian Conservation Assessment Database (ACAD; Table 3-119), as well as a moderate regional threats score (3). Its regional population trend score

Table 3-118. Average density of Scott's Oriole in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
BIBE Upland	0.02 (0.02–0.03)	14	326	14
GUMO Upland	0.06 (0.04–0.08)	15	296	3
WHSA Upland	0.01 (0.01–0.03)	42	102	7

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

Table 3-117. Average occupancy of Scott's Oriole, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
BIBE Upland	0.58 (0.44–0.76)	14	125	15	0.16 (0.10–0.25)	25	125	18
CAVE Upland	0.48 (0.28–0.72)	24	42	17	0.20 (0.11–0.37)	32	42	13
FODA Upland	–	–	–	–	0.10 (0.03–0.22)	44	15	22
GUMO Upland	0.83 (0.69–0.96)	9	115	3	0.23 (0.15–0.36)	22	115	8
GUMO Riparian	–	–	–	–	0.80 (0.49–0.99)	17	22	5
WHSA Upland	0.55 (0.32–0.81)	22	32	7	0.13 (0.06–0.24)	36	32	15

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

is relatively high (4 out of 5), indicating a decrease in population size within the region. The relative density score is a 5, indicating that the species breeds in high mean abundance, similar to the region(s) in which it occurs in maximum density. Additionally, the percentage of its global population in Bird Conservation Region (BCR) 35 is 17.0%. Scott's Oriole is considered a species of regional concern. However, because this species does not meet the criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability in the parks.

Table 3-119. Conservation status of Scott's Oriole at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	13
Federally listed under ESA	no
Regional Population Trend (PT-r)	4
Regional Threats-Breeding (TB-r)	3
Relative Density-Breeding (RD-b)	5
Percent of Global Population in BCR (% Pop)	17.0
Regional Concern	yes
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.44 Spotted Towhee (*Pipilo maculatus*)



Spotted Towhee. Credit: © ROBERT SHANTZ

Spotted Towhee (*Pipilo maculatus*) is a resident species that breeds in Big Bend NP and Guadalupe Mountains NP, and it is a nonbreeding migrant in all other park units (Appendix B). We detected it in all park units except White Sands NP. Spotted Towhee is a ground nester found in higher elevations of brushy oaks and conifers in the Chihuahuan Desert (Benson and Arnold 2001).

Occupancy and density estimates for Spotted Towhee were obtained for only one park-habitat, Guadalupe Mountains NP (GUMO) Riparian. Unconditional point occupancy of Spotted Towhee in this park-habitat was high (Table 3-120). Among species in this park-habitat, Spotted Towhee ranked second in probability of occupying a point. Spotted Towhee density in Guadalupe Mountains NP Riparian was 0.69 birds/ha (0.52–0.92), and among species in this park-habitat, Spotted Towhee ranked first in density (Table 3-121).

Spotted Towhee has a low Continental Combined Score (8) in the Avian Conservation Assessment Database (ACAD; Table 3-122). It has a moderate regional threats score (3) and a comparatively high regional population trend score (4), which indicates a population size decrease within the region. Spotted Towhee's relative density score is low (2), and the percentage of its population in Bird Conservation Region (BCR) 35 is only 1.6%. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability in the parks.

Table 3-121. Average density of Spotted Towhee in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
GUMO Riparian	0.69 (0.52–0.92)	15	104	1

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

Table 3-120. Average occupancy of Spotted Towhee, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
GUMO Riparian	–	–	–	–	0.86 (0.57–1.00)	15	70	2

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-122. Conservation status of Spotted Towhee at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	8
Federally listed under ESA	no
Regional Population Trend (PT-r)	4
Regional Threats-Breeding (TB-r)	3
Relative Density-Breeding (RD-b)	2
Percent of Global Population in BCR (% Pop)	1.6
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.45 Summer Tanager (*Piranga rubra*)



Summer Tanager. Credit: © ROBERT SHANTZ

Summer Tanager (*Piranga rubra*) is a migratory species that breeds in all park units except White Sands NP, where it is a non-breeding migrant (Appendix B). We detected it in all park units. In the breeding season, Summer Tanager is found in riparian cottonwood (*Populus*) and willow (*Salix*) woodlands (Billerman et al. 2020).

Transect occupancy of Summer Tanager was high in Big Bend NP (BIBE) Riparian and moderate at Amistad NRA (AMIS) Riparian (Table 3-123). Among species at these park-habitats, Summer Tanager did not rank high in probability of occupying a transect. Unconditional point occupancy was high in Carlsbad Caverns NP (CAVE) Riparian, and low in Guadalupe Mountains NP (GUMO) Riparian. In these park-habitats, the highest Summer Tanager ranked in probability of occupying a point was third (in Carlsbad Caverns NP Riparian).

Density of Summer Tanager was estimated only at Big Bend NP Riparian, where density was 0.14 birds/ha (0.09–0.22; Table 3-124). Among species detected at this park-habitat, Summer Tanager ranked seventh in estimated density.

Summer Tanager has a moderate Continental Combined Score (9), and a low regional population trend score (1, the lowest possible), in the Avian Conservation Assessment Database (ACAD; Table 3-125). The regional threats score (4) is relatively high, indicating vulnerability during the breeding season. The

Table 3-124. Average density of Summer Tanager in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
BIBE Riparian	0.14 (0.09–0.22)	22	103	7

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

Table 3-123. Average occupancy of Summer Tanager, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Riparian	0.60 (0.36–0.86)	21	29	16	0.39 (0.14–0.77)	40	29	16
BIBE Riparian	0.73 (0.50–0.93)	15	75	11	0.49 (0.27–0.86)	30	75	11
CAVE Riparian	–	–	–	–	0.94 (0.78–1.00)	6	44	3
GUMO Riparian	–	–	–	–	0.26 (0.12–0.54)	39	11	24

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

relative density score is moderate. The percentage of Summer Tanager's population in Bird Conservation Region (BCR) 35 is only 1.5%. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability in the parks.

Table 3-125. Conservation status of Summer Tanager at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	9
Federally listed under ESA	no
Regional Population Trend (PT-r)	1
Regional Threats-Breeding (TB-r)	4
Relative Density-Breeding (RD-b)	3
Percent of Global Population in BCR (% Pop)	1.5
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.46 Verdin (*Auriparus flaviceps*)



Verdin. Credit: © ROBERT SHANTZ

Verdin (*Auriparus flaviceps*) is a resident species that breeds in all CHDN park units (Appendix B), and we detected this species in all park units. It is the only New World species found in the family Remizidae. Verdin is a small and conspicuously loud species that builds a breeding nest, as well as a winter roosting nest, on shrubby, thorny hillsides and along arroyos (Benson and Arnold 2001).

Transect occupancy of Verdin was high at Amistad NRA (AMIS) Upland, Big Bend NP (BIBE) Upland, and Guadalupe Mountains NP (GUMO) Upland (Table 3-126). Transect occupancy was moderate at Amistad NRA Riparian, Big Bend NP Riparian, and Carlsbad Caverns NP (CAVE) Upland. Finally, transect occupancy was low at White Sands NP (WHSA) Upland. Verdin ranked ninth in probability of occupying a transect at both Big Bend NP Upland and Guadalupe Mountains NP Upland.

Density of Verdin was estimated only at Big Bend NP Upland, where it was 0.10 birds/ha (0.08–0.12; Table 3-127). Among species detected in this park-habitat, Verdin ranked fourth in density.

Verdin has a moderate Continental Combined Score (11) in the Avian Conservation Assessment Database (ACAD; Table 3-128), as well as a moderate regional threats score (3). Its regional population trend score is comparatively low (2). The relative density score is high (5 out of 5), indicating the species breeds in high mean abundance in the region, similar to the region(s) in which it occurs in maximum density. The percent of its global population in Bird Conservation Region (BCR) 35 is 10.3%. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability in the parks.

Table 3-126. Average occupancy of Verdin, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.73 (0.53–0.89)	13	61	16	0.21 (0.10–0.39)	35	61	28
AMIS Riparian	0.42 (0.22–0.70)	28	11	29	0.27 (0.07–0.83)	63	11	29
BIBE Upland	0.76 (0.62–0.88)	9	318	9	0.25 (0.18–0.35)	16	318	9
BIBE Riparian	0.66 (0.45–0.88)	17	50	13	0.36 (0.16–0.94)	52	50	19
CAVE Upland	0.39 (0.19–0.63)	29	25	18	0.19 (0.07–0.40)	43	25	14
GUMO Upland	0.70 (0.46–0.90)	17	50	9	0.18 (0.08–0.34)	36	50	15
WHSA Upland	0.31 (0.12–0.57)	36	27	14	0.23 (0.11–0.44)	36	27	8

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.
Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-127. Average density of Verdin in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
BIBE Upland	0.10 (0.08–0.12)	12	418	4

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

Table 3-128. Conservation status of Verdin at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	11
Federally listed under ESA	no
Regional Population Trend (PT-r)	2
Regional Threats-Breeding (TB-r)	3
Relative Density-Breeding (RD-b)	5
Percent of Global Population in BCR (% Pop)	10.3
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
NM Avian Conservation Partners	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.47 Vermilion Flycatcher (*Pyrocephalus rubinus*)



Vermilion Flycatcher. Credit: © ROBERT SHANTZ

Vermilion Flycatcher (*Pyrocephalus rubinus*) is a breeding species in all CHDN park units, except Guadalupe Mountains NP where it is a possible breeder (Appendix B). We detected this species in all park units except White Sands NP, with only one individual at Guadalupe Mountains NP. Vermilion Flycatcher breeds near water in widely spaced riparian woodlands with willow and cottonwood, or in open grasslands with mesquite or oak (Benson and Arnold 2001).

Transect-level occupancy of Vermilion Flycatcher was moderate in Amistad NRA (AMIS) Riparian and Big Bend NP (BIBE) Riparian (Table 3-129). Among species in these park-habitats, Vermilion Flycatcher did not rank high in probability of occupying a transect. Unconditional point occupancy in Carlsbad Caverns NP (CAVE) Riparian was high, but it did not rank high overall among species in this park-habitat.

Due to low detection numbers, we did not estimate density of Vermilion Flycatcher for any park-habitat combinations.

Vermillion Flycatcher has a low Continental Combined Score (5, the second-lowest score possible) in the Avian Conservation Assessment Database (ACAD; Table 3-130). This species also has low regional population trend (2) and relative density (2) scores. The low population trend score indicates an increase in population size within the region. Its regional threats score (3) is moderate. Less than 1.0% of Vermillion Flycatcher's global population is in Bird Conservation Region (BCR) 35. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability in the parks.

Table 3-129. Average occupancy of Vermilion Flycatcher, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.66 (0.40–0.92)	21	26	24	0.83 (0.18–1.00)	30	26	2
AMIS Riparian	0.54 (0.29–0.79)	24	38	23	0.34 (0.15–0.62)	34	38	22
BIBE Riparian	0.59 (0.37–0.86)	21	20	18	0.11 (0.03–0.32)	64	20	31
CAVE Riparian	–	–	–	–	0.81 (0.63–0.97)	11	49	11

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-130. Conservation status of Vermillion Flycatcher at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	5
Federally listed under ESA	no
Regional Population Trend (PT-r)	2
Regional Threats-Breeding (TB-r)	3
Relative Density-Breeding (RD-b)	2
Percent of Global Population in BCR (% Pop)	0.7
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

2 Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.48 Western Kingbird (*Tyrannus verticalis*)



Western Kingbird. Credit: JOHN AND KAREN HOLLINGSWORTH, USFWS

Western Kingbird (*Tyrannus verticalis*) is a migratory species breeding in all CHDN park units (Appendix B). We detected this species in all park units except Fort Davis NHS. Western Kingbird breeds in a diversity of open habitats, such as desert scrub, grassland, cropland, and open tree habitats that facilitate nesting and aerial foraging (Benson and Arnold 2001). It commonly places its nest atop the old flowering stalks of yucca.

Transect occupancy of Western Kingbird was high at White Sands NP (WHSA) Upland, and moderate at Carlsbad Caverns NP (CAVE) Upland and Guadalupe Mountains NP (GUMO) Upland (Table 3-131). Western Kingbird ranked high (second) among species in probability of occupying a transect at White Sands NP Upland.

Unconditional point occupancy of Western Kingbird was high at Carlsbad Caverns NP Riparian; this is the only park-habitat where unconditional point occupancy was estimated. Among species at this park-habitat, Western Kingbird ranked sixth in probability of occupying a point.

Western Kingbird density was estimated only at White Sands NP Upland (0.06 birds/ha [0.04–0.10]; Table 3-132). In this park-habitat, Western Kingbird ranked second in density among the small number of species for which estimates were produced.

Western Kingbird has a moderate Continental Combined Score (9), and relatively low regional population trend (2) and regional threats (2) scores, in the Avian Conservation Assessment Database (ACAD; Table 3-133). These latter two scores indicate low vulnerability. The relative density score of 4 indicates that the species breeds in moderately high mean abundance relative to the region(s) in which it occurs in maximum density. The percentage of Western Kingbird's global

Table 3-131. Average occupancy of Western Kingbird, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.68 (0.38–0.93)	22	13	22	0.03 (0.01–0.10)	57	13	32
CAVE Upland	0.64 (0.41–0.91)	20	41	13	0.10 (0.05–0.22)	41	41	17
CAVE Riparian	–	–	–	–	0.85 (0.60–0.98)	12	35	6
GUMO Upland	0.46 (0.25–0.73)	26	35	23	0.11 (0.05–0.22)	38	35	19
WHSA Upland	0.76 (0.57–0.94)	13	77	2	0.14 (0.08–0.25)	31	77	14

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

population that occurs in Bird Conservation Region (BCR) 35 is 6.0%. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability status in the parks.

Table 3-132. Average density of Western Kingbird in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
WHSA Upland	0.06 (0.04–0.10)	23	167	2

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

Table 3-133. Conservation status of Western Kingbird at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	9
Federally listed under ESA	no
Regional Population Trend (PT-r)	2
Regional Threats-Breeding (TB-r)	2
Relative Density-Breeding (RD-b)	4
Percent of Global Population in BCR (% Pop)	6.0
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.49 Western Wood-Pewee (*Contopus sordidulus*)



Western Wood-Pewee. Credit: PETER PEARSALL, USFWS

Western Wood-Pewee (*Contopus sordidulus*) is a migratory species that breeds in Carlsbad Caverns NP, Guadalupe Mountains NP, and White Sands NP; it is a possible breeder in Fort Davis NHS (Appendix B). We detected this species in each of these park units, as well as Big Bend NP. Western Wood-Pewee breeds in mountainous pine-oak woodlands and riparian woodlands (Benson and Arnold 2001).

Although transect occupancy of Western Wood-Pewee was estimated at White Sands NP (WHSA) Upland, we did not categorize occupancy (high, moderate, low) because of very low precision in the estimate (i.e., credible interval range >0.50; Table 3-134). Unconditional point occupancy was estimated at two park-habitats, but, for the same reason, we only categorized one. Unconditional point occupancy of Western Wood-Pewee was high at Guadalupe Mountains NP (GUMO) Riparian. Among species in this park-habitat, Western Wood-Pewee ranked tenth in probability of occupying a point.

Based on low detection numbers, we did not estimate density of Western Wood-Pewee for any park-habitat combinations.

Western Wood-Pewee has a moderate Continental Combined Score (12), and a moderate regional threats score (3), in the Avian Conservation Assessment Database (ACAD; Table 3-135). Its regional population trend score (4) is relatively high, indicating a recent decrease in population size within the region. Both the relative density score (2) and the percentage of the global population in Bird Conservation Region (BCR) 35 (1.3%) are comparatively low. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability status in the parks.

Table 3-134. Average occupancy of Western Wood-Pewee, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
CAVE Riparian	–	–	–	–	0.68 (0.45–0.98)	21	28	17
GUMO Riparian	–	–	–	–	0.74 (0.50–0.97)	17	38	10
WHSA Upland	0.47 (0.24–0.76)	27	28	11	0.76 (0.11–1.00)	42	28	1

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-135. Conservation status of Western Wood-Pewee at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	12
Federally listed under ESA	no
Regional Population Trend (PT-r)	4
Regional Threats-Breeding (TB-r)	3
Relative Density-Breeding (RD-b)	2
Percent of Global Population in BCR (% Pop)	1.3
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.50 White-winged Dove (*Zenaida asiatica*)



White-winged Dove. Credit: © ROBERT SHANTZ

White-winged Dove (*Zenaida asiatica*) is a common resident species breeding in all CHDN park units (Appendix B), and we detected this species in all park units. In Texas and New Mexico, White-winged Dove breeds in a diversity of dense riparian or thorny woodland habitats, desert cacti communities, or residential trees (Billerman et al. 2020).

Transect-level occupancy of White-winged Dove was high at Big Bend NP (BIBE) Riparian and Amistad NRA (AMIS) Upland (Table 3-136). It was moderate at Amistad NRA Riparian. Among species in these park-habitats, White-winged Dove ranked high in probability of occupying a transect only at Big Bend NP Riparian (second).

Unconditional point-level occupancy was high at Carlsbad Caverns NP (CAVE) Riparian and low at Guadalupe Mountains NP (GUMO) Riparian. White-winged Dove ranked first in probability of point occupancy at Carlsbad Caverns NP Riparian.

White-winged Dove density was highest in Carlsbad Caverns NP Riparian (0.36 birds/ha [0.27–0.48]), followed by Big Bend NP Riparian (0.24 birds/ha [0.19–0.29]), and lowest in Big Bend NP Upland (0.01 birds/ha [0.00–0.02]; Table 3-137). White-winged Dove density ranked second among species in Carlsbad Caverns NP Riparian, and fourth among species in Big Bend NP Riparian.

Table 3-137. Average density of White-winged Dove in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
AMIS Upland	0.09 (0.04–0.19)	38	210	14
AMIS Riparian	0.06 (0.04–0.10)	25	104	6
BIBE Upland	0.01 (0.00–0.02)	33	100	19
BIBE Riparian	0.24 (0.19–0.29)	10	520	4
CAVE Riparian	0.36 (0.27–0.48)	15	156	2
FODA Upland	0.07 (0.05–0.10)	19	177	6

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

Table 3-136. Average occupancy of White-winged Dove, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.77 (0.53–0.96)	15	64	14	0.27 (0.11–0.72)	51	64	22
AMIS Riparian	0.60 (0.39–0.83)	18	41	15	0.31 (0.14–0.58)	35	41	23
BIBE Upland	0.55 (0.27–0.85)	28	40	16	0.06 (0.01–0.27)	93	40	23
BIBE Riparian	0.92 (0.79–0.99)	6	179	2	0.49 (0.37–0.61)	12	179	10
CAVE Riparian	–	–	–	–	0.97 (0.86–1.00)	4	60	1
FODA Upland	–	–	–	–	0.31 (0.09–0.73)	50	47	15
GUMO Riparian	–	–	–	–	0.26 (0.14–0.54)	38	14	23

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

White-winged Dove has a low Continental Combined Score (7) in the Avian Conservation Assessment Database (ACAD; Table 3-138). It also has a comparatively low regional threats score (2) and a low (1) regional population score (the lowest score possible). The latter score indicates a significant, large increase in population size within the region. The relative density score of 4 indicates that the species breeds in moderately high mean abundance relative to the region(s) in which it occurs in maximum density, while the percentage of White-winged Dove's global population occurring in Bird Conservation Region (BCR) 35 is 5.0%. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability status in the parks.

Table 3-138. Conservation status of White-winged Dove at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	7
Federally listed under ESA	no
Regional Population Trend (PT-r)	1
Regional Threats-Breeding (TB-r)	2
Relative Density-Breeding (RD-b)	4
Percent of Global Population in BCR (% Pop)	5.0
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.51 Yellow-breasted Chat (*Icteria virens*)



Yellow-breasted Chat. Credit: ANTONIO CELIS-MURILLO, USGS

Yellow-breasted Chat (*Icteria virens*) is a migratory species breeding in Amistad NRA, Big Bend NP, Carlsbad Caverns NP, and Guadalupe Mountains NP (Appendix B). It is a possible breeder in Fort Davis NHS, where it has been found nesting nearby (Struthers et al. 2014). We detected Yellow-breasted Chat in all CHDN parks where it breeds. It is the sole member of the family Icteriidae, a bird of dense shrublands, weedy patches, riparian areas, and other thickets, all lacking a substantial overstory (Billerman et al. 2020). It is an occasional species (seen at least once every few years, but not necessarily every year) at Fort Davis NHS and White Sands NP.

Transect occupancy of Yellow-breasted Chat was high at Big Bend NP (BIBE) Riparian and moderate at Amistad NRA (AMIS) Riparian (Table 3-139). The highest Yellow-breasted Chat ranked in probability of occupying a transect was sixth (at Big Bend NP Riparian). Unconditional point occupancy was high at Carlsbad Caverns NP (CAVE) Riparian, and among species in this park-habitat, Yellow-breasted Chat ranked fourth in probability of point occupancy.

Yellow-breasted Chat's density was highest in Carlsbad Caverns NP Riparian (1.15 birds/ha [0.85–1.55]), followed by Amistad NRA Riparian (0.79 birds/ha [0.42–1.47]) and Big Bend NP Riparian (0.58 [0.42–0.79]; Table 3-140). Among species in these park-habitats, Yellow-breasted Chat ranked first in Amistad NRA Riparian and Carlsbad Caverns NP Riparian, and second in Big Bend NP Riparian.

Yellow-breasted Chat has a moderate Continental Combined Score (11), as well as a moderate regional threats score (3), in the Avian Conservation Assessment Database (ACAD; Table 3-141). Its low regional population trend score (1) indicates a significant, large population increase in the region. The species receives a moderate relative density score (3), and the percentage of its global

Table 3-140. Average density of Yellow-breasted Chat in CHDN parks and habitats, 2010–2017.

Park and Habitat	Density (D)			
	Birds/ha (LCL–UCL)	% CV	n	D Rank [1]
AMIS Riparian	0.79 (0.42–1.47)	31	126	1
BIBE Riparian	0.58 (0.42–0.79)	16	287	2
CAVE Riparian	1.15 (0.85–1.55)	15	149	1

[1] D Rank is the species' position in a list, with "1" being the species with the greatest estimated density in a given park-habitat.

Other definitions: LCL and UCL = lower and upper confidence limits; CV = coefficient of variation; n = number of individuals detected per park-habitat.

Table 3-139. Average occupancy of Yellow-breasted Chat, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
AMIS Upland	0.60 (0.31–0.91)	26	31	28	0.06 (0.01–0.22)	78	31	31
AMIS Riparian	0.60 (0.36–0.82)	20	73	17	0.61 (0.28–0.88)	26	73	2
BIBE Riparian	0.80 (0.61–0.96)	12	146	6	0.61 (0.31–0.90)	26	146	3
CAVE Riparian	–	–	–	–	0.93 (0.81–0.99)	5	69	4

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

population in Bird Conservation Region (BCR) 35 is 2.8%. The species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability status in the parks.

Table 3-141. Conservation status of Yellow-breasted Chat at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	11
Federally listed under ESA	no
Regional Population Trend (PT-r)	1
Regional Threats-Breeding (TB-r)	3
Relative Density-Breeding (RD-b)	3
Percent of Global Population in BCR (% Pop)	2.8
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
NM Avian Conservation Partners	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.52 Yellow-rumped Warbler (*Setophaga coronata*)



Yellow-rumped Warbler. Credit: © ROBERT SHANTZ

Yellow-rumped Warbler (*Setophaga coronata*) is present year-round and breeds in Guadalupe Mountains NP; however, the same individuals are not likely present year-round. It is a common, migratory, non-breeding species in all other park units in the CHDN (Appendix B). We detected this species in all park units. Yellow-rumped Warbler breeds in conifers of the Guadalupe Mountains above 2,100 m (6,890 feet; Benson and Arnold 2001).

We estimated occupancy of Yellow-rumped Warbler at only one park in the CHDN. Transect occupancy of this species at Guadalupe Mountains NP (GUMO) Upland was high (Table 3-142). Among species in this park-habitat, Yellow-rumped Warbler ranked seventh in probability of occupying a transect. Although we estimated unconditional point occupancy of Yellow-rumped Warbler at Guadalupe Mountains NP Riparian, we did not categorize it (high, moderate, low) because of very low precision in the estimate (i.e., credible interval range >0.50).

Based on low detection numbers, we did not estimate the density of Yellow-rumped Warbler for any park-habitat.

Yellow-rumped Warbler has a low Continental Combined Score (6) in the Avian Conservation Assessment Database (ACAD; Table 3-143). Its regional population trend (3) and regional threats (3) scores are moderate. Both its relative density score (2) and the percentage of its global population in Bird Conservation Region (BCR) 35 (0.1%) are low. For relative density, this means that Yellow-rumped Warbler breeds in low mean abundance relative to the region(s) in which it occurs in maximum density. This species is not listed under any of the remaining conservation status categories in the table, and because it does not meet any criteria for a species of conservation concern that we used in Section 2.4, we did not assess its breeding habitat availability status in the parks.

Table 3-142. Average occupancy of Yellow-rumped Warbler, by transect and point, in CHDN parks and habitats, 2010–2017.

Park and Habitat	Occupancy (Psi): Transect				Occupancy (Theta): Point			
	Psi (95% CI)	% CV	n	Psi Rank [1]	Theta (95% CI)	% CV	n	Theta Rank [1]
GUMO Upland	0.76 (0.54-0.93)	14	48	7	0.50 (0.21-0.80)	30	48	3
GUMO Riparian	–	–	–	–	0.59 (0.29-0.91)	27	15	17

[1] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

– indicates no estimate because the park-habitat combination had only one transect.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Table 3-143. Conservation status of Yellow-rumped Warbler at multiple scales (i.e., global, continental, federal, regional, and state, respectively). Entries for some scores/rankings are "yes" or "no."

Name of Score/Ranking [1, 2]	Score
NatureServe Global (G) Rank	G5
Continental Combined Score (CCS-max)	6
Federally listed under ESA	no
Regional Population Trend (PT-r)	3
Regional Threats-Breeding (TB-r)	3
Relative Density-Breeding (RD-b)	2
Percent of Global Population in BCR (% Pop)	0.1
Regional Concern	no
Regional Stewardship	no
State-listed in Texas	no
State-listed in New Mexico	no
New Mexico Avian Conservation Partners (NMACP)	no

[1] Regional scale is the Bird Conservation Region (BCR). All CHDN parks are in BCR 35 (results shown here); part of AMIS is in BCR 36 (results shown in Appendix F).

[2] Source of scores/rankings is in Section 2.4.1 for federal and state levels, and Avian Conservation Assessment Database (ACAD; Partners in Flight 2019) for all others.

3.3.1.53 Results for Species with only One Set of Estimates



Figure 3-15. Western Tanager had high unconditional point occupancy in Guadalupe Mountains NP Riparian. Photo: © ROBERT SHANTZ

There are 17 landbird species for which we have only one set of occupancy estimates based on our 2010–2017 surveys in the CHDN. We did not prepare species accounts for these species due to our limited results for them, but we discuss occupancy results for them here.

Species with only one set of estimates ranged from species known to breed in every or nearly every unit (Say's Phoebe, Eastern Meadowlark) to species known to breed only in the unit with an estimate presented (Carolina Wren in Amistad NRA). Although all of these species are surveyed effectively with diurnal point counts, detections were too low to support occupancy estimation at any additional units where classified as breeders.

Transect-level occupancy was estimated for six species in five park-habitats (Table 3-144). However, we only categorized occupancy (high, moderate, or low) for two of the estimates; precision in the other four estimates was too low (i.e., credible interval ranges >0.50). Transect occupancy of Carolina Wren was low in Amistad NRA (AMIS) Riparian. Transect occupancy of Say's Phoebe was high in Big Bend NP (BIBE) Riparian. Neither of these species ranked high among species at these park-habitats in probability of occupying a transect.

Unconditional point-level occupancy was estimated for 11 species in three park-habitats, with most of the species (8 of 11) being in Guadalupe Mountains NP Riparian. However, we only categorized occupancy (high, moderate, or low) for three of the estimates, all of which were in Guadalupe Mountains NP Riparian. Unconditional point occupancy was high for Black-headed Grosbeak, Plumbeous Vireo, and Western Tanager (Figure 3-15). Each of these species ranked high among species in this park-habitat in probability of occupying a point (third, first, and fourth, respectively).

We reviewed conservation status information for these 17 species to determine whether any are included as regional concern or stewardship species, and to look at their scores in the Avian Conservation Assessment Database (PIF 2019, 2020) to determine whether any have noteworthy (i.e., high or low) scores in three categories. These categories are regional population trend, regional threats-breeding, and relative density-breeding. These categories and regional concern/stewardship species were described in Section 3.3.1.1.

One species, Eastern Meadowlark, is of regional concern, and one species, Crissal Thrasher, is a regional stewardship species. For regional population trend, only one species has either the highest or lowest score; Eastern Meadowlark has a 5 (out of 5), indicating a significant, large decrease in population size within the region. None of these species have either the highest or lowest score for regional threats. For relative density, two species have the lowest possible score (1 out of 5), and two species have the highest possible score (5 out of 5). Carolina Wren and Indigo Bunting have a 1, which means these species "breed regularly but in very small numbers or in only a very small part of the region in question" (Panjabi et al. 2020). Crissal Thrasher and Say's Phoebe have a 5, which means they breed "in high mean abundance, similar to the region(s) in which the species occur in maximum density" (Panjabi et al. 2020). In addition, more than 30% of the global population of Crissal Thrasher occurs in Bird Conservation Region 35 during the breeding season.

Table 3-144. Average occupancy of species with only one set of occupancy estimates, by transect and point, in CHDN parks and habitats, 2010–2017. Only estimates with an asterisk (*, and red font) have a credible interval range ≤0.50.

Species	Park and Habitat	Occupancy (Psi): Transect [1]				Occupancy (Theta): Point			
		Psi (95% CI)	% CV	n	Psi Rank [2]	Theta (95% CI)	% CV	n	Theta Rank [2]
Black-crested Titmouse	FODA Upland	–	–	–	–	0.53 (0.14–0.91)	40	34	7
Black-headed Grosbeak	GUMO Riparian	–	–	–	–	0.85 (0.65–0.99) *	11	63	3
Broad-tailed Hummingbird	GUMO Riparian	–	–	–	–	0.70 (0.45–0.98)	20	36	13
Carolina Wren	AMIS Riparian	0.30 (0.12–0.58) *	38	15	31	0.46 (0.11–0.91)	44	15	8
Chipping Sparrow	GUMO Upland	0.37 (0.15–0.76)	40	19	24	0.36 (0.09–0.84)	49	19	4
Crissal Thrasher	BIBE Upland	0.60 (0.34–0.91)	25	24	14	0.67 (0.07–1.0)	41	24	3
Eastern Meadowlark	WHSA Upland	0.45 (0.21–0.83)	35	32	12	0.45 (0.03–1.0)	56	32	5
Golden-fronted Woodpecker	AMIS Riparian	0.58 (0.31–0.87)	25	19	18	0.28 (0.07–0.82)	61	19	27
House Wren	GUMO Riparian	–	–	–	–	0.58 (0.31–0.94)	27	14	18
Indigo Bunting	CAVE Riparian	–	–	–	–	0.60 (0.26–0.96)	31	11	20
Phainopepla	FODA Upland	–	–	–	–	0.52 (0.07–0.92)	47	13	9
Plumbeous Vireo	GUMO Riparian	–	–	–	–	0.93 (0.71–1.0) *	9	75	1
Violet-green Swallow	GUMO Riparian	–	–	–	–	0.60 (0.30–0.95)	28	16	16
Warbling Vireo	GUMO Riparian	–	–	–	–	0.60 (0.34–0.93)	25	27	15
Western Tanager	GUMO Riparian	–	–	–	–	0.80 (0.55–0.99) *	15	43	4
White-throated Swift	GUMO Riparian	–	–	–	–	0.72 (0.38–0.98)	23	16	11
Say's Phoebe	BIBE Riparian	0.72 (0.44–0.94) *	18	17	12	0.61 (0.21–0.96)	33	17	4

[1] – indicates no estimate because the park-habitat combination had only one transect.

[2] Rank is the order of highest (1) to lowest probability of occupancy per park-habitat; ranked separately for transect and point.

Other definitions: CI = credible interval; CV = coefficient of variation; n = number of species detections, where a detection is a 2-minute time interval during a point-visit with at least one individual detected.

Park acronyms: AMIS = Amistad NRA; BIBE = Big Bend NP; CAVE = Carlsbad Caverns NP; FODA = Fort Davis NHS; GUMO = Guadalupe Mountains NP; and WHSA = White Sands NP.

3.3.2 Occupancy and Density Discussion and Summary by Park and Breeding Habitat Guild

We obtained occupancy estimates for about 250 species-park-habitat combinations. In upland habitat surveyed, we estimated occupancy for 50 species, and in riparian habitat surveyed, we estimated occupancy for 58 species. Of these species, we obtained high precision (CV ≤10%) for a small subset (16 species in upland habitat and five species in riparian habitat). We obtained density estimates for 81 species-park-habitat combinations. We estimated density of 30 species in upland habitat and 11 species in riparian habitat.

Previous analyses in the CHDN with NPS landbird monitoring data recommended that future occupancy analyses focus on species detected frequently enough to support reliable estimates (Gould 2015). Eleven such species were highlighted: Ash-Throated Flycatcher, Black-throated Sparrow, Cactus Wren, Cassin's Sparrow, Mourning Dove, Northern Mockingbird, Pyrrhuloxia, Rufous-crowned Sparrow, Scott's Oriole, Scaled Quail, and Turkey Vulture (Gould 2015). We excluded Scaled Quail and Turkey Vulture from our analyses because they are poorly surveyed by point counts (Bibby et al. 2002, Sutherland et al. 2004, Ralph et al. 1995), but we were able to estimate occupancy for the remaining nine species for at least four parks each, and each species had at least one park-habitat combination with a CV ≤10% (i.e., with high precision).

In Section 3.3.1 (Species Accounts) of this report, we presented occupancy and density results of our analyses by bird species—approximately 50 of them. In this section of the report, we provide an overview and discussion of occupancy and density results: 1) by park, so park personnel can easily locate results most relevant to them; 2) by breeding habitat guild (see Table 2-6 in Chapter 2), to inform understanding of composition of surveyed bird communities with respect to preferred breeding habitat; and 3) for species of conservation concern, as such species are usually a high priority for park managers.

3.3.2.1 Summaries by Park

Amistad NRA

We categorized transect occupancy for 33 species (i.e., species with credible interval ranges ≤0.50) at Amistad NRA in surveyed upland and riparian habitats. Of these 33 species, 13 had estimates in upland habitat only (i.e., Barn Swallow, Black-tailed Gnatcatcher, Black-throated Sparrow, Blue-gray Gnatcatcher, Brown-headed Cowbird, Cactus Wren, Canyon Towhee, Cassin's Sparrow, Common Ground Dove, House Finch, Lark Sparrow, Pyrrhuloxia, and Rufous-crowned Sparrow), nine had estimates in riparian habitat only (i.e., Blue Grosbeak, Canyon Wren, Carolina Wren, Common Yellowthroat, Red-winged Blackbird, Rock Wren, Summer Tanager, Vermilion Flycatcher, and Yellow-breasted Chat), and 11 had estimates in both upland and riparian habitat (i.e., Ash-throated Flycatcher, Bell's Vireo, Bewick's Wren, Cliff Swallow, Mourning Dove, Northern Cardinal, Northern Mockingbird, Orchard Oriole, Painted Bunting, Verdin, and White-winged Dove).

Transect occupancy in upland habitat was high (0.67–1.0 Psi) for 20 of these species (i.e., Ash-throated Flycatcher, Bell's Vireo, Bewick's Wren, Black-throated Sparrow, Brown-headed Cowbird, Cactus Wren, Canyon Towhee, Cassin's Sparrow, Cliff Swallow, Common Ground Dove, House Finch, Lark Sparrow, Mourning Dove, Northern Cardinal, Northern Mockingbird, Painted Bunting, Pyrrhuloxia, Rufous-crowned Sparrow, Verdin, and White-winged Dove), and moderate (0.34–0.66 Psi) for four species (Barn Swallow, Black-tailed Gnatcatcher, Blue-gray Gnatcatcher, and Orchard Oriole). In riparian habitat, occupancy was high for seven of the species (Ash-throated Flycatcher, Bell's Vireo, Canyon Wren, Mourning Dove, Northern Cardinal, Painted Bunting, and Rock Wren), and moderate for 12 of the species (Bewick's Wren, Blue Grosbeak, Cliff Swallow, Common Yellowthroat, Northern Mockingbird, Orchard Oriole, Red-winged Blackbird, Summer Tanager, Verdin, Vermilion Flycatcher, White-winged Dove, and Yellow-breasted Chat). Finally, five of the species listed above had high occupancy in both

upland and riparian habitat (Ash-throated Flycatcher, Bell's Vireo, Mourning Dove, Northern Cardinal, and Painted Bunting).

Among species for which estimates are available at this park, Bell's Vireo ranked first in transect occupancy in both upland and riparian habitats. Four other species ranked in the top three in either upland or riparian habitat (Black-throated Sparrow and Northern Mockingbird in upland habitat, and Canyon Wren and Painted Bunting in riparian habitat).

At Amistad NRA, we estimated density for 18 species. We generated density estimates for 15 species in upland habitat at this park—Cliff Swallow, Black-throated Sparrow, Cassin's Sparrow, Northern Mockingbird, Pyrrhuloxia, Brown-headed Cowbird, Rufous-crowned Sparrow, Cactus Wren, Bell's Vireo, Bewick's Wren, Northern Cardinal, Mourning Dove, Painted Bunting, White-winged Dove, and Ash-throated Flycatcher (listed from highest to lowest rank in estimated density). We generated density estimates for six species in riparian habitat—Yellow-breasted Chat, Red-winged Blackbird, Northern Cardinal, Bell's Vireo, Canyon Wren, and White-winged Dove (listed in highest to lowest rank among species for which we estimated density). For three of these species (Bell's Vireo, Northern Cardinal, and White-winged Dove), we generated density estimates in both upland and riparian habitat. Additionally, across the network, Amistad NRA Upland was the only park-habitat in which we estimated densities of Bewick's Wren, Brown-headed Cowbird, Cliff Swallow, and Painted Bunting. Similarly, Amistad NRA Riparian was the only park-habitat in which we estimated density of Red-winged Blackbird.

Big Bend NP

We categorized transect occupancy for 30 species (i.e., species with credible interval ranges ≤0.50) at Big Bend NP in surveyed upland and riparian habitats. Of these 30 species, 11 had estimates in upland habitat only (i.e., Black-tailed Gnatcatcher, Blue-gray Gnatcatcher, Cactus Wren, Canyon Towhee, Cassin's Sparrow, Curve-billed Thrasher, Greater Roadrunner, Loggerhead Shrike, Pyrrhuloxia, Rufous-crowned Sparrow, and Scott's Oriole), 11 had estimates in riparian habitat only (i.e., Blue Grosbeak, Brown-headed Cowbird, Common Ground Dove, Common Yellowthroat, Ladder-backed Woodpecker, Northern Cardinal, Say's Phoebe, Summer Tanager, Vermilion Flycatcher, White-winged Dove, and Yellow-breasted Chat), and eight had estimates in both upland and riparian habitat (i.e., Ash-throated Flycatcher, Bell's Vireo, Black-throated Sparrow, House Finch, Mourning Dove, Northern Mockingbird, Rock Wren, and Verdin).

Transect occupancy in upland habitat at Big Bend NP was high (0.67–1.0 Psi) for 13 of these species (i.e., Ash-throated Flycatcher, Black-tailed Gnatcatcher, Black-throated Sparrow, Blue-gray Gnatcatcher, Cactus Wren, Curve-Billed Thrasher, Greater Roadrunner, House Finch, Mourning Dove, Northern Mockingbird, Pyrrhuloxia, Rock Wren, and Verdin), and moderate (0.34–0.66 Psi) for five species (Bell's Vireo, Canyon Towhee, Loggerhead Shrike, Rufous-crowned Sparrow, and Scott's Oriole). In riparian habitat, transect occupancy was high for 12 of the species (Ash-throated Flycatcher, Bell's Vireo, Black-throated Sparrow, Common Yellowthroat, House Finch, Ladder-backed Woodpecker, Mourning Dove, Northern Cardinal, Say's Phoebe, Summer Tanager, White-winged Dove, and Yellow-breasted Chat), and moderate for six of the species (Brown-headed Cowbird, Common Ground Dove, Northern Mockingbird, Rock Wren, Verdin, and Vermilion Flycatcher). Finally, four of the species listed above had high occupancy in both upland and riparian habitat (Ash-throated Flycatcher, Black-throated Sparrow, House Finch, and Mourning Dove).

Among species for which estimates are available in Big Bend NP, Black-throated Sparrow ranked first in transect occupancy in upland habitat, and Bell's Vireo ranked first in transect occupancy in riparian habitat. Also, in upland habitat, Black-tailed Gnatcatcher and Cactus Wren ranked second and third, respectively, and in riparian habitat, White-winged Dove and Northern Cardinal ranked second and third, respectively.

We estimated density for 23 species at Big Bend NP. We generated density estimates for 15 species in upland habitat only. Listed from highest to lowest rank among species for which we estimated density in this park-habitat, these species were Black-throated Sparrow, Black-tailed Gnatcatcher, Cactus Wren, Verdin, House Finch, Pyrrhuloxia, Northern Mockingbird, Rufous-crowned Sparrow, Canyon Towhee, Rock Wren, Scott's Oriole, Cassin's Sparrow, Curve-billed Thrasher, Loggerhead Shrike, and Greater Roadrunner. We estimated density for four species in riparian habitat only—Yellow-breasted Chat, Northern Cardinal, Common Yellowthroat, and Summer Tanager (listed from highest to lowest rank in density). We estimated density for four species—Ash-throated Flycatcher, Bell's Vireo, Mourning Dove, and White-winged Dove—in both upland and riparian habitats. Additionally, across the network, Big Bend NP Upland was the only park-habitat in which we estimated densities of Black-tailed Gnatcatcher, Canyon Towhee, Curve-billed Thrasher, Greater Roadrunner, House Finch, Loggerhead Shrike, and Verdin. Similarly, Big Bend NP Riparian was the only park-habitat in which we estimated densities of Common Yellowthroat and Summer Tanager.

Carlsbad Caverns NP

We categorized transect occupancy for 15 species (i.e., species with credible interval ranges ≤0.50) at Carlsbad Caverns NP in surveyed upland habitat. These species, ranking highest to lowest in transect occupancy, were Black-throated Sparrow, Blue Grosbeak, Rufous-crowned Sparrow, Mourning Dove, House Finch, Ash-throated Flycatcher, Canyon Towhee, Cassin's Sparrow, Northern Mockingbird, Pyrrhuloxia, Cave Swallow, Brown-headed Cowbird, Western Kingbird, Scott's Oriole, and Verdin. Transect occupancy in upland habitat at Carlsbad Caverns NP was high (0.67–1.0 Psi) for all of these species except Brown-headed Cowbird, Scott's Oriole, Verdin, and Western Kingbird, which had moderate occupancy (0.34–0.66 Psi).

We surveyed only one transect in riparian habitat; therefore, we estimated unconditional point occupancy only for 16 species in this habitat—Ash-throated Flycatcher, Bell's Vireo, Black-chinned Hummingbird, Brown-headed Cowbird, Cassin's Kingbird, Common Yellowthroat, House Finch, Ladder-backed Woodpecker, Northern Cardinal, Northern Mockingbird, Painted Bunting, Summer Tanager, Vermilion Flycatcher, Western Kingbird, White-winged Dove, and Yellow-breasted Chat. White-winged Dove, House Finch, and Summer Tanager ranked in the top three in unconditional point occupancy among species at this park-habitat.

At Carlsbad Caverns NP, we estimated density for 11 species. Nine species had density estimates in upland habitat (Black-throated Sparrow, Cave Swallow, Rufous-crowned Sparrow, Northern Mockingbird, Blue Grosbeak, Mourning Dove, Cassin's Sparrow, Ash-throated Flycatcher, and Pyrrhuloxia, listed from highest to lowest rank in density). We estimated density for two species in riparian habitat, Yellow-breasted Chat and White-winged Dove, with Yellow-breasted Chat ranked first. Across the network, Carlsbad Caverns NP Upland was the only park-habitat in which we estimated densities of Blue Grosbeak and Cave Swallow.

Fort Davis NHS

With only one transect surveyed in upland habitat, we estimated only unconditional point occupancy at Fort Davis NHS. We categorized point occupancy for nine species (i.e., species with credible interval ranges ≤0.50) in surveyed upland habitat (Ash-throated Flycatcher, Bewick's Wren, Black-throated Sparrow, Cactus Wren, Canyon Wren, House Finch, Mourning Dove, Northern Mockingbird, and Scott's Oriole). Point occupancy was not high for any of these species, but Black-throated Sparrow and Canyon Wren had moderate occupancy (0.34–0.66 Theta). The highest-ranking species in point occupancy at this park-habitat was Black-throated Sparrow.

We estimated density for seven species at Fort Davis NHS—Black-throated Sparrow, Rufous-crowned Sparrow, Rock Wren, Canyon Wren, Ash-throated Flycatcher, White-

winged Dove, and Cassin's Kingbird (listed from highest to lowest rank in density). Across the network, Fort Davis NHS was the only park in which we estimated density of Cassin's Kingbird.

Guadalupe Mountains NP

We categorized transect occupancy for 15 species (i.e., species with credible interval ranges ≤0.50) at Guadalupe Mountains NP in surveyed upland habitat. Species with estimates in upland habitat were Ash-throated Flycatcher, Bewick's Wren, Black-throated Sparrow, Brown-headed Cowbird, Cactus Wren, Canyon Towhee, House Finch, Mourning Dove, Northern Mockingbird, Pyrrhuloxia, Rufous-crowned Sparrow, Scott's Oriole, Verdin, Western Kingbird, and Yellow-rumped Warbler. Transect occupancy in upland habitat at Guadalupe Mountains NP was high (0.67–1.0 Psi) for 10 of these species (Ash-throated Flycatcher, Black-throated Sparrow, Brown-headed Cowbird, Cactus Wren, House Finch, Mourning Dove, Northern Mockingbird, Scott's Oriole, Verdin, and Yellow-rumped Warbler), and moderate (0.34–0.66 Psi) for three of the species (Canyon Towhee, Pyrrhuloxia, and Western Kingbird). Black-throated Sparrow, Northern Mockingbird, Scott's Oriole, Mourning Dove, Ash-throated Flycatcher, and House Finch, ranked first through sixth, respectively, in transect occupancy at this park-habitat. Additionally, we estimated transect occupancy for Yellow-rumped Warbler only at Guadalupe Mountains NP (out of the network parks surveyed).

We surveyed only one transect in riparian habitat at this park. Therefore, we estimated only unconditional point occupancy for 14 species in this habitat (i.e., Ash-throated Flycatcher, Bewick's Wren, Black-headed Grosbeak, Blue-gray Gnatcatcher, Brown-headed Cowbird, House Finch, Plumbeous Vireo, Rufous-crowned Sparrow, Scott's Oriole, Spotted Towhee, Summer Tanager, Western Tanager, Western Wood-Pewee, and White-winged Dove). Point occupancy estimates were high (0.67–1.0 Theta) for 10 species, while all other species had low estimates (Brown-headed Cowbird, House Finch, Summer Tanager, and White-winged Dove; 0.01–0.33 Theta). In riparian habitat, Plumbeous Vireo, Spotted Towhee, Black-headed Grosbeak, Western Tanager, Scott's Oriole, and Rufous-crowned Sparrow ranked first through sixth, respectively, in point occupancy.

At Guadalupe Mountains NP, we estimated density for eight species. In upland habitat, seven species had density estimates—Black-throated Sparrow, Ash-throated Flycatcher, Scott's Oriole, Mourning Dove, Northern Mockingbird, Cactus Wren, and Pyrrhuloxia, listed from highest to lowest rank in density at this park-habitat. We estimated density for one species, Spotted Towhee, in riparian habitat. Across the network, Guadalupe Mountains NP was the only park in which we estimated density of Spotted Towhee.

White Sands NP

We categorized transect occupancy for 10 species (i.e., species with credible interval ranges ≤0.50) at White Sands NP in surveyed upland habitat (Ash-throated Flycatcher, Black-throated Sparrow, Blue Grosbeak, Cactus Wren, Cassin's Sparrow, House Finch, Northern Mockingbird, Scott's Oriole, Verdin, and Western Kingbird). Transect occupancy in upland habitat was high (0.67–1.0 Psi) for three of these species (Black-throated Sparrow, Northern Mockingbird, and Western Kingbird), and moderate (0.34–0.66 Psi) for four species (Ash-throated Flycatcher, Cactus Wren, House Finch, and Scott's Oriole). Among species for which transect occupancy was estimated at this park, Black-throated Sparrow, Western Kingbird, Northern Mockingbird, Ash-throated Flycatcher, House Finch, and Scott's Oriole ranked highest (listed in descending order).

We estimated density for seven species in upland habitat at White Sands NP—Black-throated Sparrow, Western Kingbird, Horned Lark, Northern Mockingbird, Ash-throated Flycatcher, Mourning Dove, and Scott's Oriole (listed from highest to lowest rank in density). Across the network, White Sands NP was the only park in which we estimated densities of Horned Lark and Western Kingbird.

White Sands NP upland habitat generally had lower density estimates for the same species occurring in upland habitat at other CHDN parks. Transect occupancy was also generally lower at White Sands NP than in upland habitat at other network parks. Lower vegetation substrate availability may explain lower bird species occupancy and density rates in White Sands. Occupancy and density estimates were highest for common species, such as Black-throated Sparrow (0.66 transect occupancy [Psi]; 0.33 birds/ha).

3.3.2.2 Occupancy and Density by Breeding Habitat Guild

In upland habitat surveyed, the shrubland breeding habitat guild comprised the most species with occupancy estimates (15 species, 55 park-species estimates). We were able to obtain estimates in all surveyed uplands for six species (Ash-throated Flycatcher, Black-throated Sparrow, Cactus Wren, House Finch, Mourning Dove, and Northern Mockingbird). The six species are in the shrubland or upland generalist guilds. In riparian habitat surveyed, the woodland breeding habitat guild comprised the most species with occupancy estimates (17 species, 29 estimates), and the shrubland guild comprised the second most (15 species, 23 estimates). We estimated occupancy in all four park riparian areas for five species (Brown-Headed Cowbird, Ash-throated Flycatcher, House Finch, Summer Tanager, and White-winged Dove). The five species are in the woodland, upland generalist, or riparian/wetland guilds. Our occupancy results further support the importance of riparian areas for improved species richness and compositional diversity in national park units.

For density estimates in riparian habitat surveyed, the riparian/wetland breeding habitat guild comprised the most species (six species, 10 estimates). In riparian habitat, the species with the three highest densities were all in the riparian/wetland guild: Bell's Vireo in Big Bend NP, and Yellow-breasted Chat in Carlsbad Caverns NP and Amistad NRA. We estimated density of Yellow-breasted Chat and White-winged Dove in three of the four riparian areas surveyed.

For density estimates in upland habitat surveyed, the shrubland breeding habitat guild had the most species (11 species, 27 estimates), followed by the upland generalist guild (eight species, 21 estimates). In upland habitat surveyed, the species with the highest density was Cliff Swallow in the riparian/wetland guild in Amistad NRA. In all six park upland habitats surveyed, Black-throated Sparrow of the shrubland guild had consistently high estimated densities, with all six estimates in the top nine for upland estimates. Ash-throated Flycatcher, in the upland generalist guild, also had density estimated in all six park uplands, but it had consistently low densities (i.e., 0.02–0.07 birds/ha). Mourning Dove and Northern Mockingbird are both in the upland generalist guild and had density estimates in all parks except Fort Davis NHS.

3.3.2.3 Species of Conservation Concern

We estimated occupancy and/or density for seven species of conservation concern. Two of these species (Bell's Vireo and Black-chinned Sparrow) were included in Table 3-1, and the other five were addressed only in the species accounts because of the additional SCC categories included there. The seven species are: Bell's Vireo (state-threatened in New Mexico), Black-chinned Sparrow (continental watch list species), Cactus Wren (regional concern), Cassin's Sparrow (regional concern), Loggerhead Shrike (regional concern), Lucy's Warbler (regional concern), and Scott's Oriole (regional concern). An additional species, Common Ground Dove, is endangered in New Mexico, but it does not breed in the two New Mexico parks so we did not include it as an SCC.

Two of the seven species (Black-chinned Sparrow and Lucy's Warbler) had only one or two sets of occupancy estimates and no density estimates. Furthermore, the occupancy estimates for both species had very low precision (i.e., credible interval ranges >0.50), so we did not categorize occupancy (as high, moderate, or low). Four of the remaining five species each had several occupancy estimates, while Loggerhead Shrike had three transect occupancy estimates (but only one with credible interval range ≤0.50). Each of these five species had density estimates—one

for Loggerhead Shrike, three each for Cactus Wren, Cassin's Sparrow, and Scott's Oriole, and four for Bell's Vireo.

For transect occupancy, four of the species had estimates we categorized as high (0.67–1.0 Psi):

- Bell's Vireo in AMIS Upland*, AMIS Riparian*, and BIBE Riparian*
- Cactus Wren in AMIS Upland, BIBE Upland*, and GUMO Upland
- Cassin's Sparrow in AMIS Upland and CAVE Upland, and
- Scott's Oriole in GUMO Upland*.

Of these estimates, five ranked in the top three species for density among species in that park-habitat; they are denoted with an asterisk above.

For unconditional point occupancy, two of the species had estimates we categorized as high (0.67–1.0 Theta):

- Bell's Vireo in CAVE Riparian, and
- Scott's Oriole in GUMO Riparian.

The one density estimate for Loggerhead Shrike was in Big Bend NP Upland. Estimates for the other four species are as follows:

- Bell's Vireo in AMIS and BIBE Upland and Riparian
- Cactus Wren in AMIS Upland, BIBE Upland, and GUMO Upland
- Cassin's Sparrow in AMIS Upland, BIBE Upland, and CAVE Upland, and
- Scott's Oriole in BIBE Upland, GUMO Upland, and WHSA Upland.

Of the density estimates for these five species, the estimate was highest for Bell's Vireo in Big Bend NP Riparian (1.10 birds/ha). This species ranked first in density among species in this park-habitat. Other species ranking high in density among species in particular park-habitats include: Cactus Wren in Big Bend NP Upland (third), Cassin's Sparrow in Amistad NRA Upland (third), and Scott's Oriole in Guadalupe Mountains NP Upland (third).

4 Considerations for Future Monitoring

During the life of any monitoring program, its value is best maintained through an adaptive approach in which there may be iterative evolution in aspects ranging from study design to core monitoring questions (Lindenmayer and Likens 2010). From a statistical design standpoint, an ongoing monitoring effort should iteratively use the data collected for examining whether and how the effort can efficiently achieve monitoring objectives (Reynolds 2012). In the case of CHDN landbird monitoring, this translates to ensuring that future results lead to accurate conclusions about changes—accurate estimates of magnitude of change, the ability to detect undesired changes before they are irreversible, and the ability to infer that trends in survey data truly indicate changes in bird communities. This chapter focuses on using results of initial CHDN monitoring to assess the current design and options for improving its effectiveness.

Based on working with CHDN monitoring data collected through 2017, we were concerned that high year-to-year variation in survey timing could hinder trend detection by adding significant noise to the data. More importantly, we were concerned about the longer-term challenge of discriminating between true underlying population and community changes versus variation in absolute (calendar) survey timing or in survey timing relative to breeding season phenology. Therefore, we provide qualitative recommendations for managing variability in survey timing to reduce noise and potential bias in trend estimation. With up to seven years of data collected to date, CHDN has a solid platform for quantitatively evaluating the current design and potential design modifications. Using results from analyses reported in Chapter 3, we present power analyses assessing the ability of the current design to detect trends in CHDN breeding bird populations and communities. We examine how power would be affected by a less frequent survey schedule in contrast to the current annual sampling schedule, as well as by a reallocation of spatial sampling effort to increase transect sample sizes per park-habitat.

4.1 Seasonal Timing of Surveys

Repeating point-count surveys annually within the same period is important to obtain precise information about bird populations. In addition, it allows stronger certainty that estimated trends are actual changes in abundance and distribution, rather than artifacts of migration or variation in detectability throughout the breeding cycle. In this section, we synthesize existing literature regarding timing of annual point-count surveys of breeding birds.

For much of the continental United States, the recommended timing of breeding-season point-count surveys is from May 1st to the first week of July (Ralph et al. 1993, 1995). However, the southwestern U.S. experiences earlier breeding and nesting activity. Migrants that winter in the region leave early, and some species begin nesting activities as early as mid-March (Ralph et al. 1993, Butler 2003). On the other hand, annual surveys performed too early have the potential to be influenced by short-term changes in weather and residual migrants passing through (Best 1981, Butler 2003). Annual fluxes in phenology will affect early breeding migrant arrival, and even though surveys can be adjusted annually to correspond to the changes, it would require close monitoring of signs of Spring and weather patterns each year (Best 1981, Ralph et al. 1993). In addition, early breeding migrants nest less synchronously compared to later arrivals (Best 1981). This means that surveys slightly later in the season have the ability to detect the presence of both early and later-breeding migrants, as early migrants have more dispersed nesting periods.

Surveying late in the season has its own downfalls. Early season breeding migrants may be poorly detected later in the season due to decreased vocalizations in late or completed stages of nesting, and mid-season neotropical migrants may also exhibit lower detectability depending on behavior during nesting (Best 1981). In addition, birds have been migrating earlier; a comprehensive, global estimate of mean changes over time for all groups of birds from multiple studies

found an advance of 3.7 (0.70 SE) days per decade (Parmesan 2007). In the context of long-term monitoring, late surveys have the potential to miss documenting species historically detectable at that time and may need to be shifted earlier. Otherwise, it would be unclear whether the changes detected in bird populations are due to actual population shifts or long-term phenological shifts altering detectability.

For the reasons described above, mid-season surveys would allow for the most flexibility for both short- and long-term phenological change while not being tied to yearly variations in phenology. Mid-season surveys also have the greatest potential to monitor early, mid-, and late-season breeders. It is recommended that surveys each year are completed within 10 days, and between years the start dates are not more than seven days apart (Ralph et al 1993).

Therefore, bird point-count surveys performed annually for long-term monitoring of bird populations in the southwestern U.S. should be conducted within a 10-day window in mid-April. Previous monitoring surveys have ranged from March 28th to June 30th, which is too broad and increases uncertainty both by adding additional among-year variability and by making it harder to assess the meaning of estimated population changes. Logistical constraints will likely limit the ability to survey all parks within the 10-day period. Primary goals for monitoring should be used to determine trade-offs between logistical constraints and analysis goals. Specifically, CHDN landbird monitoring focuses primarily on changes within a park over time, rather than on among-park comparisons; therefore, each park should attempt to maintain start dates within seven days between years, but the 10-day survey window may vary by park.

Even if the 10- and 7-day recommendations are followed, there will still be a need to assess the possibility that perceived changes in populations are a result of changes in optimal detection dates. Climate change is predicted to affect migration and breeding timing, species distributions, and geographical ranges (Parmesan and Yohe 2003, Crick 2004, Parmesan 2007). Season-long audio recordings or surveys can be used to graph detectability curves throughout the breeding season (Best 1981, McClure et al. 2011). Confirmation that point counts are occurring during the optimal detection period would indicate true population changes. Consideration should be given to creating bird species' baselines for season-long detection curves. This would allow for appropriate determination of optimal detectability shifts. In addition, it could be used to inform survey timing specific to each park or the region. Emphasis could be placed on optimal detection times of species of particular interest, or maximum species detectable in one 10-day period.

The potential for climate change-driven phenological changes in arrival and breeding times should be investigated to allow for shifts in the 10-day survey window. Bird species have been documented migrating both earlier and later, but the magnitude of earlier arrival is greater than delayed arrival (Butler 2003, Parmesan 2007, Hüppop and Hüppop 2011). Based on the estimate of 3.7 (0.70 SE) days earlier per decade (Parmesan 2007), we recommend reassessing survey timing every 10–20 years, assuming surveys are happening across the 10-day recommended time frame. If surveys are being completed in less than 10 days, reassessment may be needed sooner. In addition, one cost-effective way to monitor for phenological shifts could be to use early and late arrivers as indicators to assess or adjust survey timing. For example, if late arrivers are not being detected, then the annual start date of surveys may need to be later, or if early arrivers are not being detected, then the start of surveys may need to be advanced. Long-term phenological changes may create a need to shift the 10-day survey window, and future annual surveys should start within seven days of the adjusted date. Consistency in survey timing will play an important role in reducing uncertainty and improving estimates.

4.2 Power Analysis

4.2.1 Overview

Statistical power is the probability of detecting a real trend of a given magnitude and form

(i.e., correctly rejecting the statistical null hypothesis of no trend), based on a specific survey design (e.g., number of transects, points per transect, and revisit frequency), expected spatial-temporal variation in the attribute being monitored (e.g., year-to-year variation in true richness), expected measurement variation (e.g., expected precision in estimates of yearly richness), and acceptable probability of Type 1 error (i.e., alpha level). Based on Beaupré et al. (2013), we examined power to detect 3% per year relative declines, focusing on species richness and occupancy. We assumed trend analyses would be conducted at alpha = 0.05 (i.e., allowing a 5% chance of incorrectly rejecting the null hypothesis of no trend when there is no trend). For long-term monitoring studies, power increases as more years of data are collected, and power analyses typically focus on determining the earliest year when a program is expected to achieve suitable power. For ecological monitoring and other field studies that deal with highly variable aspects of the ecosystem, such as breeding bird richness and occupancy, a level of 0.80 is commonly set as the threshold to acceptable power. Therefore, we examined the number of years needed to obtain a 0.80 probability (i.e., 80%) of correctly rejecting the null hypothesis of no trend when there truly is a 3% annual decline.

For this analysis, we focused on two metrics: species richness for each park-habitat combination and transect occupancy for park-habitat combinations that used the hierarchical survey design (transects and points within transects). We omitted density from these analyses for several reasons. Based on results presented in Chapter 3 and Appendices C, D, and E, density analyses produced intermediate precision compared to richness and occupancy. Occupancy estimates had lowest precision, with current analyses highly constrained by the low number of transects in most parks. Therefore, richness is likely the attribute for which trend detection is most feasible, while trend detection is most limited for occupancy. [1]

As discussed later in this chapter, the potential design changes we examined for species richness and occupancy would have comparable or intermediate effects on power to detect changes in density. Design options for achieving acceptable precision in annual density estimates and power to detect trends were examined in Beaupré et al. (2013).

Collectively across these two metrics, we examined two aspects of the landbird survey design: revisit design, and spatial replication/allocation. All analyses focused on single-panel revisit designs; that is, all monitoring sites within a park-habitat were on the same schedule of visits over years, consistent with the current design. All examinations assumed no change in number of visits per sampling year to each point (one for most park-habitats, two for parks-habitats with one transect). For species richness, we focused on comparing the current "every year" (labeled "annual") revisit design to two designs with less frequent visits chosen based on discussion with NPS monitoring staff: a) a design with five consecutive years of sampling and five consecutive years without sampling in each 10-year period ("5-5" design), and b) one with three consecutive years of sampling and seven consecutive years without sampling in every 10-year period ("3-7" design).

For occupancy analysis, we compared the annual and 3-7 revisit designs. Given the slight differences observed in power observed for 3-7 versus 5-5 designs for species richness analyses, we omitted the 5-5 design from computer-intensive occupancy power simulations. For occupancy monitoring, a major limitation of the current CHDN design is the

[1] Note: The average CV in yearly park-habitat richness estimates was 11.5%. By comparison, for estimates of park-habitat across-year averages, the average CV was 20% for density, with yearly estimates having much lower precision (see Appendix E). For across-year estimates of average transect occupancy, the average CV across park-habitats was 19%, but a more meaningful picture of precision in occupancy estimates is provided by the credible interval ranges reported for across-year estimates in Chapter 3 and for yearly estimates in Appendix D. These ranges frequently approached or exceeded 0.5, i.e., spanning nearly half or more of the entire range of possible values (0–1) for occupancy. In our results, objectively low-quality occupancy estimates (i.e., credible interval widths >0.50) generally had associated CVs of only 20 to 40%. This suggests that the CV has limited utility for comparing relative precision in estimates of occupancy probability versus density and richness.

low level of spatial replication at the transect scale for most parks, as reflected in both Dr. Bill Gould's occupancy modeling (Gould 2015) and the analyses presented earlier in this report. Therefore, we focused on comparing the current design, which has up to 20 transects (Big Bend NP Upland) per park-habitat and 16 points per transect in most upland transects, to designs with up to 40 transects in a park-habitat combination and either 16 or 9 points per transect. We did not compare alternative spatial sampling designs for species richness because we expected that any increase in spatial replication over the current design would increase power by only a small amount (see below).

4.2.2 Species Richness

This analysis focused on power to detect a 3% per year relative decline in park-habitat species richness for breeding landbirds that are surveyed effectively with point counts (see Chapter 2, Section 2.5.1). We used a simulation approach with simulated system-level and observation variances derived from park-habitat annual species richness estimates from this report (see Appendix G, Technical Details, for more information). **Under the current annual revisit design and assumed variance component values, a 3% decline per year in species richness could be detected after 13–16 years of monitoring** (Table 4-1). After 15 years of monitoring, a 3% annual decline would produce a cumulative 37% decline in species richness. By the time power to detect a decline reached 0.80, an absolute decline in richness of 10–21 species would have occurred, depending on baseline richness (Table 4-1).

Given the relatively high precision of yearly park-habitat richness estimates obtained with the current design, the primary factor constraining power is the assumed magnitude of random year-to-year variation on top of any systematic trend. This constraining effect of year-to-year variability is common in ecological monitoring (Urquhart and Kincaid 1999, Urquhart 2012). Therefore, reallocation of sampling effort to increase the number of transects per park-habitat combination likely would have minor effects on power to detect a trend in park-habitat overall richness. For example, based on additional exploratory simulations for Big Bend NP Riparian and White Sands NP Upland

Table 4-1. Power calculations for CHDN species richness monitoring under annual revisit design based on detection of a 3% per year decline in richness and log-linear regression trend analysis at alpha = 0.05. Estimates of yearly variation, average estimation variation, and average richness for CHDN species are from richness analyses of birds classified as breeders in a park and surveyed effectively with point counts.

Park	Habitat	CV_Year	CV_Estimation	Baseline Richness	Years [2]	Richness Change [3]
Amistad NRA	Riparian	9	14	55	16	-21.2
	Upland	7	13	47	15	-17.2
Big Bend NP	Riparian	(8) [1]	11	46	14	-16.0
	Upland	9	12	39	15	-14.3
Carlsbad Caverns NP	Riparian	5	12	35	14	-12.2
	Upland	9	10	40	15	-14.7
Fort Davis NHS	Upland	10	12	39	16	-15.0
Guadalupe Mountains NP	Riparian	8	12	41	15	-15.0
	Upland	5	11	46	13	-15.0
White Sands NP	Upland	(9) [1]	8	30	14	-10.4

[1] Yearly variation was not estimable with the variance partitioning approach used; values in parentheses were used.

[2] Years = number of years of monitoring to achieve 0.80 power.

[3] Richness Change = change in richness between start of monitoring and year power reaches 0.80.

monitoring, if measurement variance was reduced to essentially zero through increased sampling effort or at the analysis stage (e.g., hierarchical modeling rather than the independent modeling for each park-habitat used in the richness analyses presented in this report), the number of years to detect a 3% trend would drop by only 2–3 years. Conversely, we note that our estimates of this yearly variance component may be underestimates (see Appendix G, Technical Details), and thus we likely underestimate the number of years needed to achieve desired power.

Using Big Bend NP Upland as a representative example, 0.80 power was achieved after 15 years of monitoring for the annual revisit design, 21 years for the 5-5 revisit design, and 22 years for the 3-7 revisit design. Thus, there is the obvious trade-off between reducing cost by reducing visit frequency versus maintaining current power. These differences among revisit designs would be similar for other park-habitats.

4.2.3 Occupancy Power Analysis

For occupancy power analysis, we focused primarily on power to detect a relative 3% per year decline in transect occupancy, focusing on park-habitat combinations for which transect occupancy is meaningful (Big Bend NP and Amistad NRA Upland and Riparian; Carlsbad Caverns NP, Guadalupe Mountains NP, and White Sands NP Upland). We again set 0.80 power as the threshold for adequate power, with alpha level of 0.05 (i.e., 80% chance of detecting a true relative decline of at least 3% per year in transect occupancy if such a trend is present, with a 5% chance of incorrectly concluding there is a trend when no trend is present). With more limited analyses, we also examined power to detect a 3% relative annual decline in point occupancy at parks with only one transect (Guadalupe Mountains NP and Carlsbad Caverns NP Riparian, Fort Davis NHS Upland).

We used a simulation approach to examine a range of scenarios for baseline transect occupancy, conditional point occupancy, detection probability, number of transects, and number of points per transect. Each attribute had two or more alternative values as follows:

- revisit design: annual and less frequent monitoring with three consecutive years of monitoring followed by seven years with no monitoring each decade (3-7 revisit design)
- number of transects per park-habitat: 8, 10, 12, 16, 20, 25, 30, 35, and 40
- number of points per transect: 9 and 16
- baseline transect occupancy (Psi): 0.10, 0.25, 0.50, 0.75, and 0.90
- conditional point occupancy (Theta): 0.10, 0.25, 0.50, 0.75, and 0.90
- detection probability per 2-minute survey interval (p): 0.25, 0.50, and 0.75.

Combining the various levels of the six attributes above resulted in 2,160 monitoring scenarios. For annual revisit scenarios, we assessed power after the following number of years of monitoring: 10, 15, 20, 25, 30, 35, 40, 45, and 50. For 3-7 revisit design simulations, we assessed power after 11, 13, 21, 23, 31, 33, 41, 43, 51, and 53 years of monitoring. As the 3-7 design assumed monitoring was conducted in years 1–3, 11–13, 21–23, etc., power increased in a stepwise pattern for this design, with no change in power in years 4–10, 14–20, etc., when no data collection would occur. For each year of power assessment in each scenario, we performed 100 replicate simulations, as each set of 100 replicates was computer intensive.

We adapted transect-level simulation code and performed a smaller set of power simulations for park-habitats with only one transect. We estimated power of the annual and 3-7 revisit schedules to detect 3% annual relative declines in point occupancy based on the current number of points (Fort Davis NHS Upland: 26; Carlsbad Caverns NP Riparian: 8; Guadalupe Mountains NP Riparian: 16). We did not examine scenarios with increased spatial effort, because there is little room to increase the number of points in these park-habitats while maintaining the desired distance between points. We examined design options of annual and 3-7 revisit schedules and 8, 16, and 26 points. We examined parameter values of 0.10, 0.25, 0.50, 0.75, and 0.90 for initial point occupancy and for 2-minute detection probability levels. We combined design options and parameter lev-

els to form 150 point-level monitoring scenarios. For more information, see Appendix G, Technical Details.

4.2.3.1 General comparison of transect-level monitoring scenarios

In this section we examine general patterns in transect-level power results across the simulated monitoring scenarios. In the subsequent section, we translate these general results into expected power for each park-habitat. Of the 2,700 monitoring scenarios we simulated, 473 were treated as failed scenarios in which suitable power to detect a 3% per year decline in transect occupancy could not be achieved. This included 66 scenarios for which problems with model convergence during maximum-likelihood fitting led to unusable estimates (62 scenarios with initial transect occupancy of 0.10; four scenarios with initial transect occupancy of 0.25 and initial conditional point occupancy of 0.10). The other failed scenarios were simulation combinations that did not approach the target objective of 0.80 within the simulated half-century of monitoring (specifically, did not produce power >0.75, with this lower threshold chosen to avoid discarding scenarios that might have achieved the 0.80 level with more replications or another couple of years of simulated monitoring). Most of these additional failed scenarios were from the 3-7 revisit schedule with initial transect occupancy of 0.10–0.25 (275 failures), or were annual revisit scenarios with initial transect occupancy of 0.10 (103 failures). **Collectively, these 473 failed simulation scenarios indicate the difficulty of obtaining useful data for species with very localized occupancy within a park-habitat (i.e., those with initial transect occupancy of 10%) unless there are much greater numbers of transects than the current maximum (20 for Big Bend NP Upland).** For the 3-7 revisit design, when initial transect occupancy was 0.10, all scenarios with less than 30 transects failed. For the annual visit design, when initial transect occupancy was 0.10, all scenarios with less than 16 transects failed.

Focusing for the remainder of this section on non-failed scenarios, we examined the relative effects of the various simulation factors in determining power. To quantify overall effects of each simulation factor, we conducted a linear model analysis to estimate the effects of the simulation factor levels on the number of years needed to achieve adequate power. The linear model regression coefficients provided estimates of the average difference in number of years to achieve adequate power for the highest power level of a factor versus the lowest power level of that factor (e.g., for revisit design, annual vs. 3-7 alternatives; for transects, 40 vs. 8 transects; for points, 16 vs. 9 points per transect) (Figure 4-1). On average, baseline transect occupancy had the greatest impact on the number of years to achieve power, with power decreasing sharply as baseline Psi changed from 0.90 (i.e., a species occurring on most transects in a park-habitat) to 0.10 (i.e., a relatively rare species). Number of transects had the next biggest effect on potential power, with 8-transect scenarios taking an average of 17 years longer to achieve sufficient power than 40-transect scenarios. On average, the annual revisit design could obtain suitable power 10 years sooner than the 3-7 design, but this is an underestimate of the negative impacts of a 3-7 design on power because it does not account for the large number of failed 3-7 scenarios noted above.

Over the ranges of values examined, the number of points per transect (9 vs. 16) and the detection probability per 2-minute survey window (0.25, 0.50, 0.75) had meaningful impacts on power only when conditional transect occupancy was low. This is expected. With the hierarchical design, conditional point occupancy is the major factor driving uncertainty about whether a transect is occupied in a given year, as it takes only one detection in one occupied point to confirm transect-level occupancy. The lower the conditional point occupancy, the more points it takes on average to confirm occupancy and eliminate uncertainty about the occupancy of the transect. When conditional point occupancy is 0.10, (i.e., in transects where the species occurs, it on average occurs at only 10% of points within the transect), dropping from 16 to 9 points per transect increases the number of years needed for adequate power by about 7.5 years *if* the number of

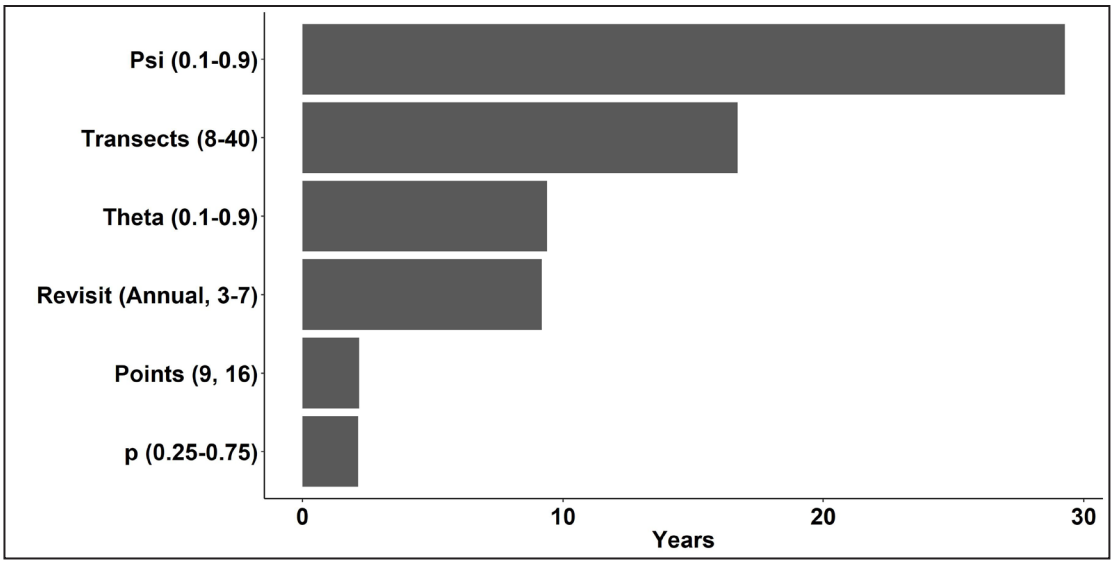


Figure 4-1. Sensitivity of power to factors examined in occupancy power simulations (longer bar = higher sensitivity). Each bar shows the average increase in number of years needed to achieve adequate power when the corresponding factor changes from its highest power to lowest power level, sorted from most to least influential factor. For example, monitoring scenarios with baseline transect occupancy (Psi) of 0.10 take nearly 30 years longer to achieve adequate power compared to those with Psi = 0.90. Scenarios with detection probability per 2 minute interval (p) of 0.25 take <2 years longer to achieve adequate power than scenarios with p = 0.75.

transects is kept constant. As will be seen below, decreasing the number of points from 16 to 9 and allocating effort to increase the number of transects has some benefits for power to detect changes in transect occupancy. Note that had we considered further reductions in points (e.g., to 6 or 3 points per transect), there would have been a significant loss of power in reducing points below 9 for a broader range of conditional point occupancy values. When conditional point occupancy is 0.25 or higher, the power cost of reducing the number of points from 16 to 9 becomes trivial. **Averaged over all simulation scenarios, when the number of transects was held constant, reducing the number of points per transect from 16 to 9 delayed achievement of adequate power by only two years on average.**

The factor of least overall importance in driving power was detection probability, keeping in mind that we did not examine detectability values below 0.25 and that simulations did not include heterogeneity in p. Again, the only exception to this general pattern was when conditional point occupancy was very low (0.10); in this situation, monitoring with detection probabilities of 0.50 and 0.75 achieved adequate power 5–7 years earlier compared to when p was only 0.25. Still, for breeding landbirds effectively surveyed and detected with point counts, achievable power is not highly sensitive to detection probability.

For the remainder of this general comparison of simulation scenarios, we summarize general relationships between power to detect a 3% annual decrease in transect occupancy versus number of transects, baseline transect occupancy, and, to a lesser degree, number of points. For context, we note that a 3% per year relative decline in transect occupancy scales to a 50% relative decline from initial occupancy after 23 years (e.g., if initial occupancy is 0.50, a 3% per year decline produces a drop in transect occupancy to 0.25 after 23 years). By years 30, 40, and 50, respectively, occupancy would have decreased by ~60, 70, and 78% relative to its initial value in year 1.

For a species that is widespread in a park-habitat (baseline transect occupancy of 0.75), desired power can be reached within 12–21 years of monitoring with annual monitoring, depending on the level of transect replication (Figure 4-2 [A]). For a species that is not widespread across a park-habitat (baseline transect occupancy of 0.25), none of the cur-

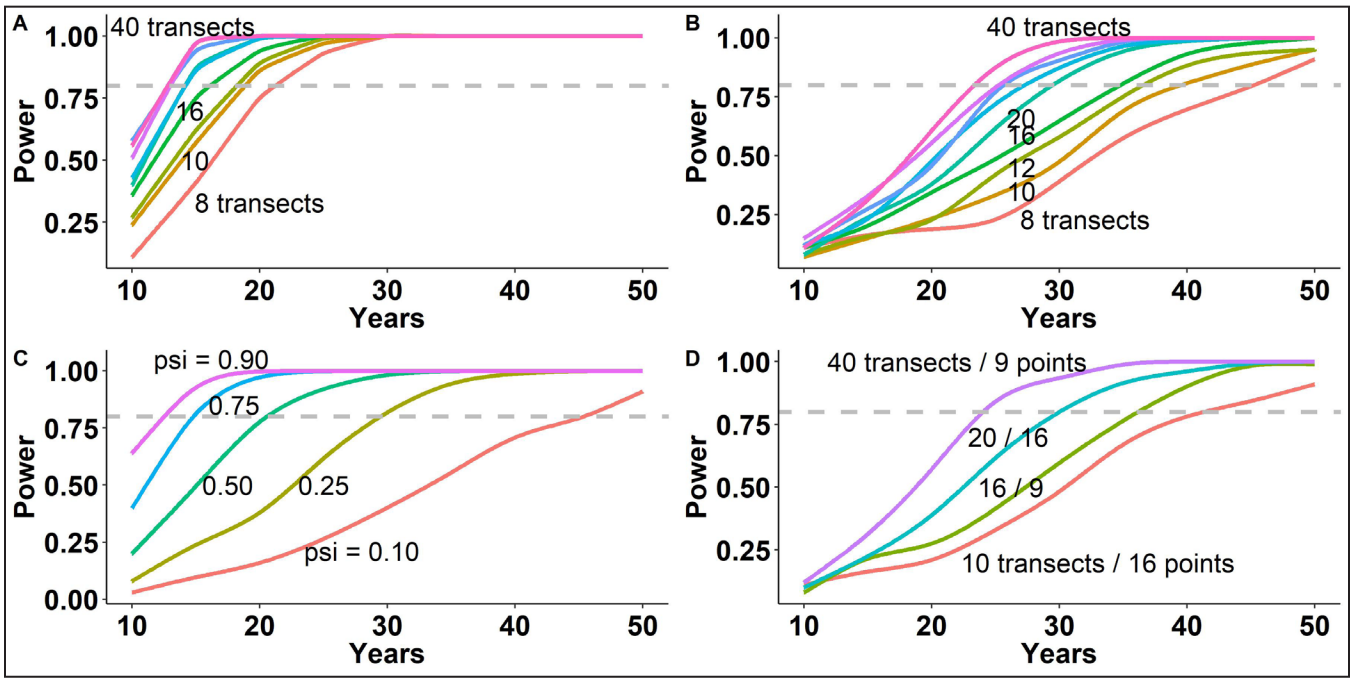


Figure 4-2. Power to detect a 3% relative decline in transect occupancy by year of monitoring for annual revisits, 16 points per transect unless otherwise noted, conditional point occupancy = 0.50, and detection probability = 0.50. Dashed horizontal line = target power of 0.80. A) Power by number of transects (8, 10, 12, 16, 20, 25, 30, 35, and 40) with baseline transect occupancy = 0.75. Labels for some curves are omitted but transect steps increment from right to left. B) Same as A but with baseline transect occupancy = 0.25. C) Power by initial transect occupancy (Psi) with 20 transects. D) Comparative power for 4 combinations of transect and point replication (initial transect occupancy and conditional point occupancy = 0.25).

rent CHDN levels of transect replication (≤ 20) achieve desired power within 30 years of monitoring, and the time to achieve 0.80 power increases dramatically as transect number decreases to eight transects (Figure 4-2 [B]). **The relationship between initial transect occupancy and power is a conundrum for CHDN occupancy monitoring. Monitoring of occupancy is intended to allow insights into trends for moderately common and less common species for which precise monitoring of density may not be achievable. Yet power to detect declines in transect occupancy for species with initial transect occupancy less than 0.50 may take 30 or more years even in Big Bend NP Uplands, with its current 20 transects (Figure 4-2 [C]).**

As noted earlier, there is little loss of power in reducing the number of points per transect from 16 to 9, except when conditional point occupancy is low. (However, note that a decrease in points per transect without an increase in transect sample size would reduce the number of detections available for modeling detection probability in density estimation). Even when baseline transect occupancy is low, if this reduction in points per transect is accompanied by a modest increase in number of transects, there is an increase in power to detect changes in occupancy. For example, if initial transect occupancy and conditional point occupancy are 0.25, there is a several year decrease in years needed to detect a change if the design changes from 10 transects of 16 points each to 16 transects of 9 points each (Figure 4-2 [D]). With greater proportional increases in transect replication, the benefits of the design modification increase (e.g., compare 20 transects of 16 points each, as in Big Bend NP Upland, to 40 transects of 9 points each; Figure 4-2 [D]). Moreover, such an increase in transect replication also provides much more flexibility for modeling transect-level, year-to-year extinction/colonization dynamics. Although occupancy analyses presented in Chapter 3 incorporated a transect-level, dynamic occupancy model, the sample size of transects and number of years was simply too low to provide useful estimates of year-specific, transect-level dynamics, even when modeled with random effects to partially pool information across years.

4.2.3.2 Power of current and potential CHDN occupancy monitoring (transect-level focus)

We used the general scenarios above to examine power for species with occupancy results summarized in Chapter 3 for each park-habitat combination. We categorized each species into one of the combinations of initial transect occupancy, conditional point occupancy, and detection probability (see Appendix G for more information). For each park-habitat, we tallied the cumulative number of species projected to achieve 0.80 power to detect a 3% annual decline in transect occupancy for each 5-year time step of monitoring.

For the current design (annual revisits with numbers of transects and points per transects as per monitoring to date), the relative number of species achieving adequate power reached its maximum by year 35 in Big Bend NP Upland, and by years 40–45 in most other park-habitats (Figure 4-3). In Carlsbad Caverns NP, Guadalupe Mountains NP, and White Sands NP Uplands, of the species that achieved adequate power by year 50 of monitoring, only one-half or fewer achieved adequate power by year 25. Perhaps somewhat surprisingly, Amistad NRA Upland was comparable to Big Bend NP Upland in showing a relatively high rate of accumulation of species achieving adequate power, even though the former currently has only half the number of transects as the latter. This reflects the high proportion of Amistad NRA Upland species (of those with usable estimates) that were widespread across most transects in that park-habitat. Of the species included in results shown in Figure 4-3, 71% of Amistad NRA Upland species had baseline transect occupancy (i.e., posterior median occupancy estimates from Chapter 3) of 0.675 or higher, compared to only 20-55% of species in other park-habitats.

As expected based on general simulation results described above, power was strongly related to how widespread a species was within a park-habitat at the start of monitoring. **Specifically, for species with baseline transect occupancy at the 0.90 level, on average, adequate power was achieved in 16.4 years. As baseline transect occupancy decreased, time to achieve adequate power increased (0.75 level: 22.1 years; 0.50 level: 30.7 years; 0.25 level: 41 years, with no species with baseline transect occupancy of 0.10 achieving adequate power within 50 years). This further emphasizes that for assessing declines in transect occupancy, within the first three decades the current design is useful mainly for detecting changes in species that are fairly widespread within a park-**

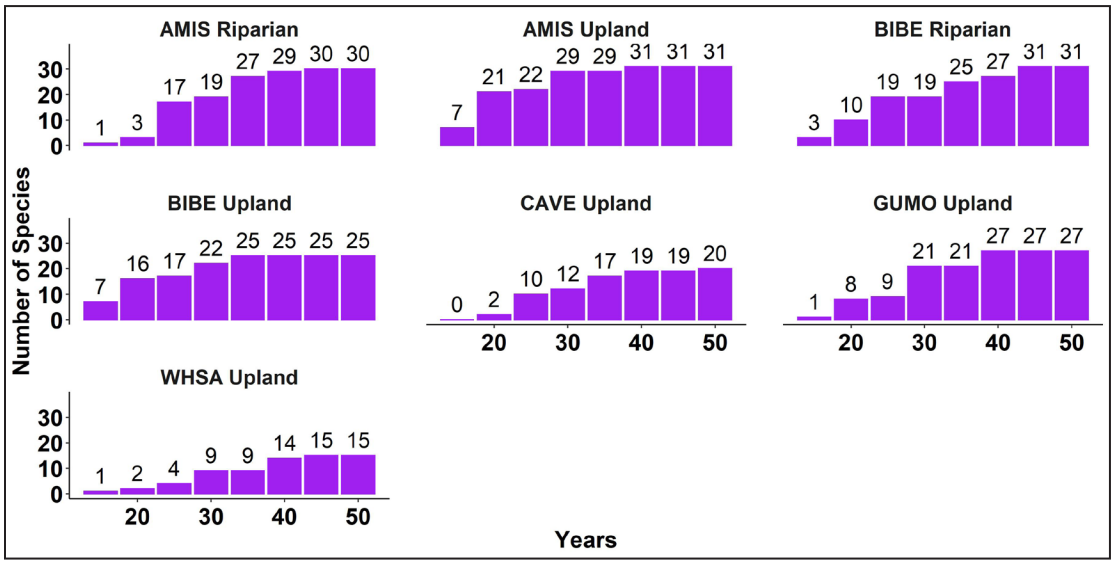


Figure 4-3. Power of current CHDN design for transect occupancy: cumulative number of species by 5-year time step for which current spatial design with annual revisits achieves 0.80 power to detect 3% annual relative decline in transect occupancy.

habitat—those occurring initially at 50% or more of transects.

Across the five parks for which upland transect occupancy was examined, most of the 118 species-park-habitat combinations achieving adequate power by year 50 with the current design were categorized as being in shrubland (46) or upland generalist (33) breeding habitat guilds. Species in the grassland-savanna guild achieving adequate power in multiple park uplands included Blue Grosbeak (Amistad NRA, Carlsbad Caverns NP, Guadalupe Mountains NP, and White Sands NP), Cassin's Sparrow (all five parks), Lark Sparrow (Amistad NRA, Carlsbad Caverns NP, and Guadalupe Mountains NP), and Loggerhead Shrike (Big Bend NP and Guadalupe Mountains NP). Of the 61 species-park riparian combinations achieving desired power by year 50, most were in the riparian-wetland (22), shrubland (16), or upland generalist (14) guilds.

If the current spatial design (number of transects and points per transect) was maintained, but a switch to a 3-7 revisit schedule was made, power of the design declines accordingly (Figure 4-4). Assuming monitoring occurs in the first three years of each decade, even after year 53 the 3-7 revisit design would not have caught up to the annual revisit schedule in terms of number of species achieving adequate power. With further years of monitoring, the 3-7 design would eventually achieve power comparable to the annual design, but possibly not until after there have been drastic changes in species occurrence.

We examined two alternative design options in which annual revisits were retained but number of transects per park-habitat were increased. In one option, we increased the number of transects per park-habitat by 50–60% (from 8 to 12 in Carlsbad Caverns NP Upland, from 20 to 30 in Big Bend NP Upland, and from 10 to 16 in other park-habitats). In the second option, we doubled the current number of transects (8 to 16, 10 to 20, 20 to 40). We also report a third alternative design in which the number of transects was doubled but with a shift to a 3-7 revisit schedule. With all three options, the number of points per transect was reduced—from 16 to 9 for upland transects and maintained at 9 for riparian transects.

With annual revisits and a 50–60% increase in transects, the number of species for which acceptable power is achieved by years 25–30 increases by up to 50% in Amistad NRA Riparian and Big Bend NP Riparian (Figure

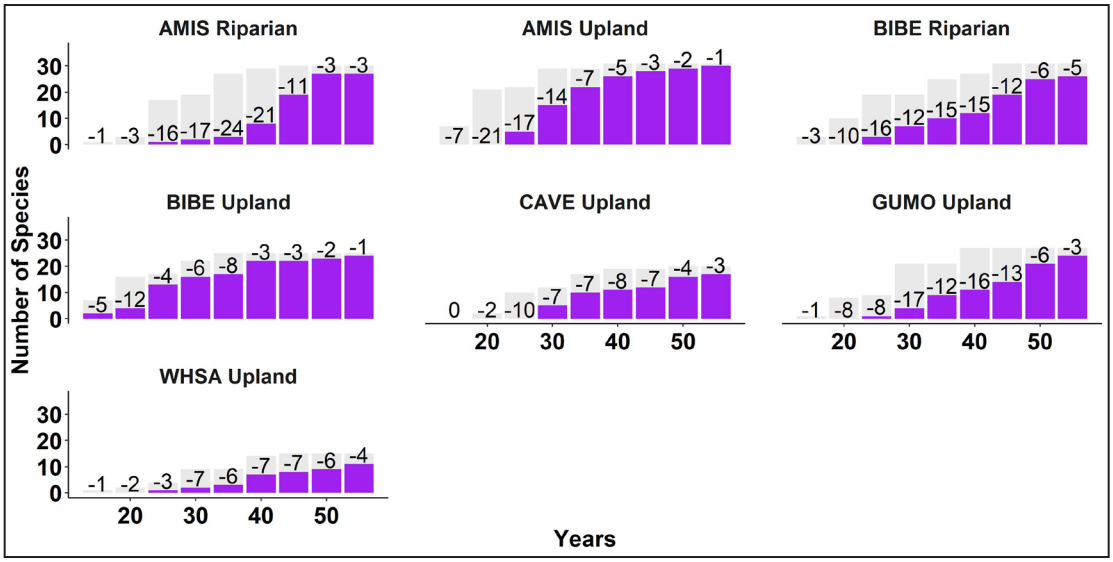


Figure 4-4. Power of the modified, 3-7, CHDN design for transect occupancy: purple bars = cumulative number of species by 5-year time step for which current spatial effort but 3-7 revisit schedule achieves 0.80 power to detect 3% annual relative decline in transect occupancy. Light gray bars are for current design with annual revisits as in Figure 4-3; numbers are the differences between the two revisit designs in the number of species achieving adequate power.

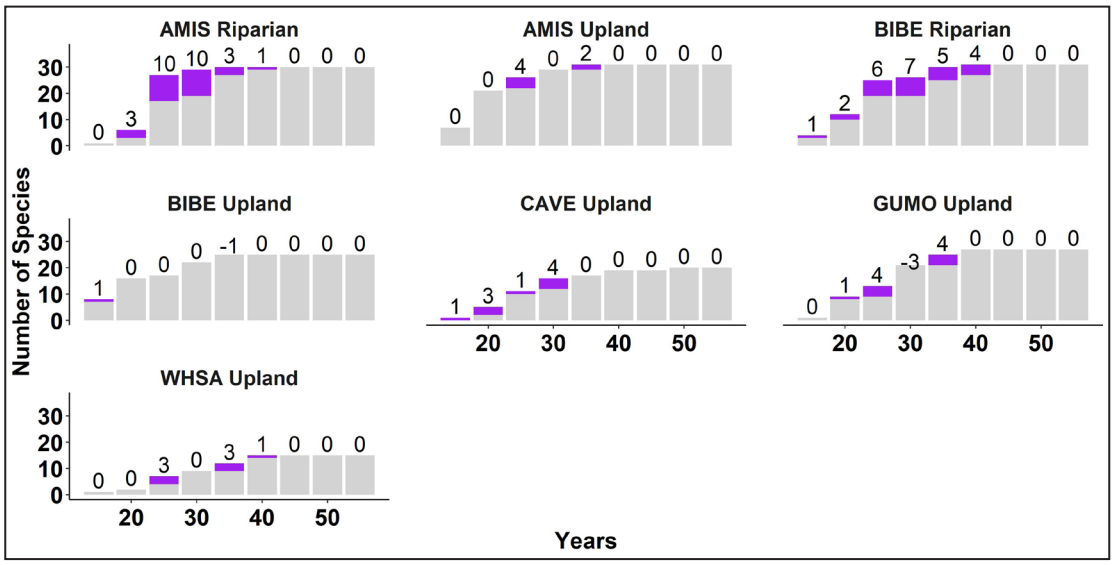


Figure 4-5. Difference in number of species achieving 0.80 power for detecting a 3% decline in transect occupancy by year, comparing designs with 50–60% more transects per park-habitat and 9 points per transect vs. current design. Gray bars = numbers for current design as in Figure 4-3. Purple bar and number labels = change in number of species with modified design. [Note: there are two bars indicating decreased power with increased effort; this is just an artifact of simulation variability.]

4-5). If the number of transects is doubled compared to the current design, there is a more consistent increase in the number of species achieving adequate power within the first three to four decades of monitoring. We also note that there are additional potential benefits to increasing the number of transects. First, as noted previously, increased transect replication would increase flexibility for modeling transect-level occupancy dynamics for each species (e.g., allowing more meaningful monitoring of year to year variability in transect-level turnover in occupancy (i.e., extinction/colonization dynamics). Second, our assessment of power for occupancy analyses was limited to species for which meaningful occupancy estimates could be produced using the existing data produced to date by the current design. Comparing the number of species per park-habitat achieving adequate power within 50 years under the current design (Figure 4-3) versus the estimated average yearly richness of breeding birds surveyed effectively with point counts for each park-habitat (Table 4-1), the current design gave us sufficient information to estimate power meaningfully for 50–67% of the relevant species in these park-habitats. We speculate that with increased transect replication of 50–60%, or especially 100% more transects, adequate power could be achieved within 50 years for additional species per park-habitat beyond what is shown in Figures 4-5 and 4-6.

The third modified design option we examined also consisted of 100% more transects than the current design and nine points per transect, but with a 3-7 revisit schedule. Compared to the current design, this third modification came with a loss in the number of species achieving adequate power before year 55 of monitoring (Figure 4-7). Again, a major trade-off is maximizing power versus ensuring cost-effectiveness. For example, for Big Bend NP Upland, with a doubling of transect numbers but with nine points per transect and dropping seven years of monitoring per decade, there would be about 1,080 total point visits (40 transects x 9 points/transect x 3 years) per decade compared to 3,200 point visits under the current design. Transect visits per decade for Big Bend NP Upland would drop from 200 to 120.

4.2.3.3 Power of current and potential CHDN occupancy monitoring (point-level focus)

For park-habitats where only unconditional point occupancy is relevant (Carlsbad Caverns NP and Guadalupe Mountains NP Riparian; Fort Davis NHS Upland), we again used occupancy estimates from Chapter 3 for each park-habitat combination. We catego-

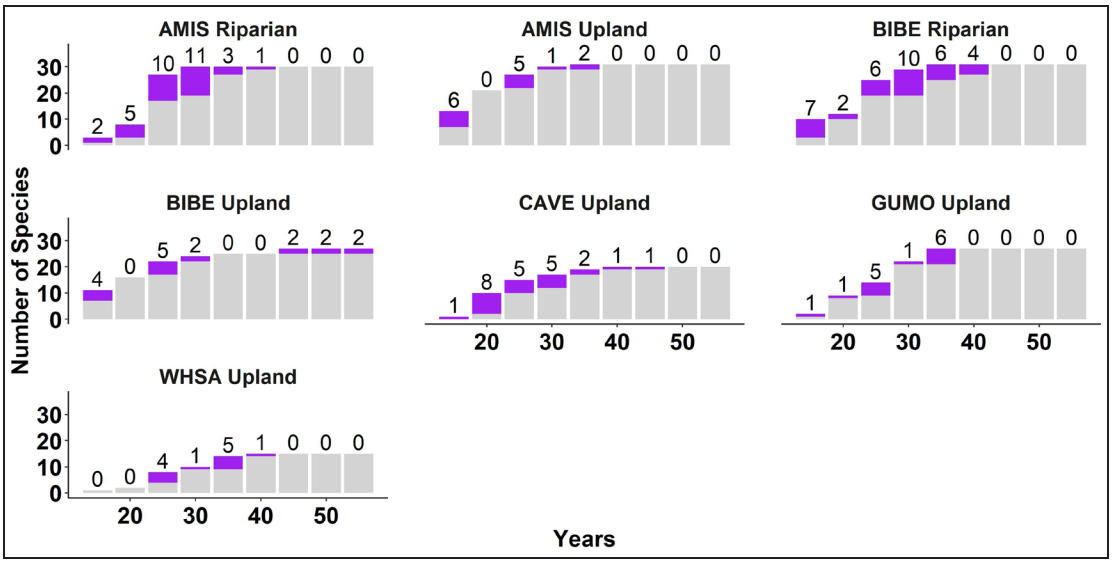


Figure 4-6. Difference in number of species achieving 0.80 power for detecting 3% decline in transect occupancy by year, comparing designs with a 100% increase in number of transects per park-habitat (i.e., number of transects doubled) and 9 points per transect vs. current design. Gray bars = numbers for current design as in Figure 4-3. Purple bars and number labels = change in number of species with modified design.

rized each species into one of the simulated combinations of initial point occupancy and detection probability (see Appendix G for more information). For each park-habitat,we tallied the cumulative number of species projected to achieve 0.80 power to detect a 3% annual decline in point occupancy for each 5-year time step of monitoring.

For the current design with annual revisits, the relative number of species achieving adequate power reached its maximum by years 35–45 in the three park-habitats (Figure 4-8 [A]). Of the species for which current data allowed us to produce meaningful occupancy estimates, 12–15 species per park-habitat achieved adequate power by year 30, and 22–26 species achieved adequate power by year 50. For Fort Davis NHS Upland, most of the 26 species achieving adequate power by year 50 were categorized as shrubland (12), upland generalist (7), or wood-

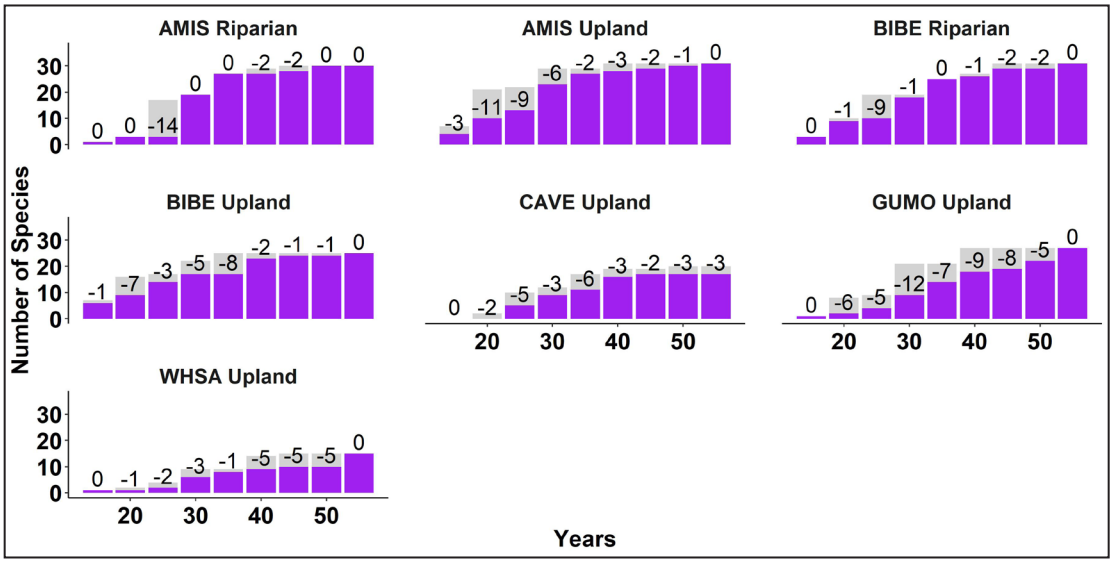


Figure 4-7. Difference in the number of species achieving 0.80 power for detecting a 3% decline in transect occupancy by year, comparing designs with a 100% increase in number of transects per park-habitat and 9 points per transect but with a 3-7 revisit schedule vs. current design. Gray bars = numbers for current design as in Figure 4-3. Purple bars and number labels = change in number of species with modified design.

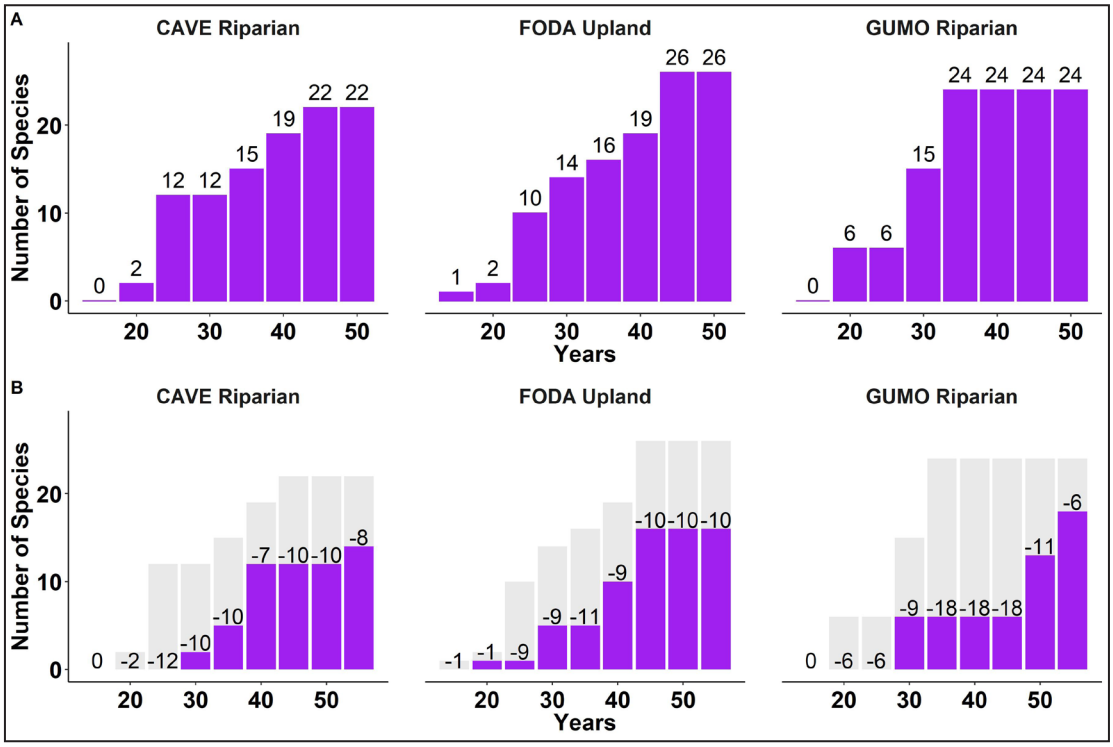


Figure 4-8. Power of CHDN design for point occupancy under A) annual revisit schedule and B) 3-7 revisit schedule. Purple bars = cumulative number of species by 5-year time step for which current spatial effort achieves 0.80 power to detect a 3% annual relative decline in point occupancy. In B), light gray bars are for annual revisits as in A; numbers are the difference between the annual and 3-7 revisit schedules in number of species with adequate power.

land species (5), with Blue Grosbeak and Cassin's Sparrow as the only grassland/savanna species. For Carlsbad Caverns NP and Guadalupe Mountains NP Riparian, most of the species achieving adequate power were woodland (18 species-park combinations out of 46 total), upland generalist (12), riparian-wetland (8), or shrubland (7) species. As with transect occupancy, the majority of the species-park-habitat combinations for which adequate power is achieved are species widespread at the point scale. Specifically, of the 72 species-park-habitat combinations achieving adequate power by year 5, 53 had median point occupancies of 0.375–1.0. Of the seven species-park-habitat combinations with baseline point occupancy of <0.15, adequate power was not achieved until year 45 of monitoring, on average.

For these three park-habitats, changing to a 3-7 revisit schedule would markedly reduce the number of species for which adequate power would be achieved within 50 years (Figure 4-8 [B]). This reduction in power from switching to a 3-7 schedule is more severe for these park-habitats compared to park-habitats evaluated for transect occupancy (see Figure 4-4). **Even after 55 years of monitoring, switching to a 3-7 schedule (compared to the annual design) would result in 25–38% fewer species with adequate power to detect a decline in point occupancy.**

4.2.4 Summary of Richness and Occupancy Power Results

For trend estimation in ecological monitoring programs, the most important aspect of sample size is generally the number of years elapsed since the start of monitoring. Requiring one to three decades of monitoring to achieve high power (≥0.80) to detect a modest yearly trend is typical for ecological monitoring (e.g., Urquhart and Kincaid 1999, Symstad et al. 2012, Urquhart 2012). With the current spatial effort and annual monitoring, a 3% per year decline in park-habitat species richness can be detected within approximately 15 years. A 3% per year decline in occupancy could be detected for wide-

spread species within large park-habitats in 20–25 years, whereas detecting such a trend would take at least three to five decades for less widespread species. We focused on a 3% per year decline for consistency with protocol objectives, but we emphasize that this magnitude of trend produces fairly drastic changes within 15 to 20 years (Beaupré et al. 2013). Detecting more gradual trends would take longer. For example, for species richness in Big Bend NP Upland, detecting relative declines of 2% and 1% per year would take 19 and 30 years, respectively (based on additional exploratory simulations), compared to about 15 years for a 3% per year decline.

Collecting data less frequently to save costs, such as with the 3-7 revisit schedule, would lengthen the time needed to detect a 3% per year trend by about seven years for species richness. For occupancy, effects would be more severe; even after 50 years, the 3-7 revisit schedule would not have caught up to the current design in terms of number of species for which adequate power would be achieved. The 3-7 design may be most useful for assessing large-scale changes in species composition. That being said, although we limited our simulations to 50 to 55 years, even the 3-7 schedule would eventually allow detection of changes in occupancy if applied consistently for many decades.

Our power simulations show that an increase in number of transects by 50–100% and a reduced number of points per transect (nine in our simulations) would provide modest increases in the number of species per park-habitat for which adequate power is achieved in the first few decades of monitoring (see Figures 4-5 and 4-6). As reported in Chapters 2 and 3, with additional data and a very flexible modeling approach, we were able to estimate occupancy for more species compared to Gould (2015), while explicitly modeling transect-level occupancy dynamics (transect-scale extinction-colonization dynamics). Although we used a Bayesian framework for the occupancy analyses in Chapters 2 and 3, this dynamic, hierarchical model (Green et al. 2019) can be fit via maximum-likelihood in program "MARK," which was not the case at the time of Gould's (2015) analyses.

Given these advances, the modest benefits of increased transect sample sizes shown in Figures 4-5 and 4-6, and the number of species for which we reported occupancy estimates in Chapter 3, it may be easy to underestimate the limitations imposed by the current sample sizes of transects for monitoring transect-scale occupancy. However, we strongly second Gould's (2015) assessment that the current sample size of transects is problematically low (8–20) in CHDN park-habitats where transect-scale occupancy is the primary scale of interest. For analyses in Chapters 2–3, our ability to model transect-scale dynamics—i.e., to fit models that produce useful estimates of transect-scale extinction/colonization parameters—was severely limited by the current number of transects. Even with a highly flexible analysis in a Bayesian framework, and after assuming no yearly variation in park-habitat-specific transect-scale extinction/colonization parameters, we achieved very poor precision in estimates of park-habitat transect-scale dynamics. With more years of data, there would be somewhat higher flexibility for modeling such changes, but we expect that the power of future transect-scale occupancy analyses would always be severely constrained by the current low number of transects per park-habitat (8–20). Reallocating effort from point-level replication to transect-level replication would likely offer significant benefits to future analyses of changes in richness, composition, and density as well. It would allow greater ability to assess among-transect variation in trends, achieve adequate power despite this variation, and allow more meaningful examination of factors potentially driving this variation (Urquhart 2012, Weiser et al. 2019).

5 Conclusions

The CHDN, within the NPS I&M Program, designated three monitoring objectives for the landbird monitoring protocol (Beaupré et al. 2013). The first was to "estimate the proportion of sites occupied for most species in most parks, with the goal of detecting a 3% annual decline over a 30-year period" (Beaupré et al. 2013). The second objective was to "monitor density of the most common species with the goal of detecting a 3% annual decline over a 30-year period" (Beaupré et al. 2013). The third was more general with the objective of "estimating parameters related to community dynamics, particularly species richness and species composition" (Beaupré et al. 2013). Monitoring was stratified into grassland and riparian, and while other habitat types exist, the protocol prioritizes identifying changes in avian communities of these two habitat types (Beaupré et al. 2013). Areas designated as a part of the grassland monitoring include shrubland and shrubland/grassland mosaic. Management and natural events have the ability to alter those areas to grassland (Beaupré et al. 2013) and vice versa. Therefore, we referred to the grassland survey area as "upland."

We performed and reported analyses to best suit these objectives with the short-term data available. With five to seven years of data available, trend analysis at this point would suffer from low power to detect trends (see Chapter 4, power analysis) and low ability to separate systematic change from shorter-term, year-to-year variability (Keith et al. 2015, Gitzen et al. 2018). Therefore, we reported on park-habitat status in occupancy, density, and species richness and composition.

In total, we detected 104 breeding species that are well-surveyed by the methods used during our annual surveys from 2010–2017. Across parks and habitats, we obtained occupancy estimates for about 250 species-park-habitat combinations. In upland habitat surveyed, we estimated occupancy for 50 species, and in riparian habitat surveyed, we estimated occupancy for 58 species. Similarly, across parks and habitats, we obtained density estimates for 81 species-park-habitat combinations. We estimated density of 30 species in upland habitat and 11 species in riparian habitat. We were able to estimate occupancy and/or density for seven species of conservation concern: Bell's Vireo (state-threatened in New Mexico), Black-chinned Sparrow (continental watch list species), Cactus Wren (regional concern), Cassin's Sparrow (regional concern), Loggerhead Shrike (regional concern), Lucy's Warbler (regional concern), and Scott's Oriole (regional concern). For two of these seven species (i.e., Black-chinned Sparrow and Lucy's Warbler) we had only one or two sets of occupancy estimates and no density estimates, and the occupancy estimates had very low precision (i.e., credible interval ranges >0.50). There are 17 landbird species for which we have only one set of occupancy estimates based on our 2010–2017 surveys in the CHDN.

In the species composition analysis of uplands, the grassland/savanna breeding habitat guild had the least or second least number of species for all but one park. This is unsurprising, as grassland breeding species richness is relatively low in the Chihuahuan Desert compared to other grassland regions of North America (Peterjohn and Sauer 1999). Wintering grassland specialists are more common, and the region provides critical wintering habitat for North American grassland species (Wilsey et al. 2019). Both wintering and breeding grassland specialists are dependent on unfragmented grassland, which is in decline in the Chihuahuan Desert due to shrub encroachment, past grazing practices, and altered fire regimes (Van Auken 2000, Pidgeon et al. 2001, Nadeau et al. 2014, Nadeau et al. 2017, Valentine-Darby et al. 2016). The current prevalence of shrubs in CHDN uplands is apparent from bird species composition, as the shrubland breeding habitat guild comprised the largest proportion of species in the upland habitat surveyed of every park. Low detections and rarity of grassland species are expected, but there is still concern for their decline (Rosenberg et al. 2016).

Overall, nine species that breed in grasslands and are well-surveyed by point counts were detected during surveys. We were able to estimate occupancy in at least one park-habitat for two-thirds of grassland breeding species (Blue Grosbeak, Cassin's Sparrow, Eastern Meadowlark, Horned Lark, Lark Sparrow and Loggerhead Shrike) and density in at least one park-habitat for about half of grassland breeding species (Blue Grosbeak, Cassin's Sparrow, Horned Lark, and Loggerhead Shrike). Collectively, these results indicate the potential for monitoring some species in this declining group.

Results from CHDN landbird monitoring reinforce the contribution of riparian areas to overall park- and network-level biodiversity. In Amistad NRA and Big Bend NP, riparian species richness was higher than in surveyed upland habitat. The dominant breeding habitat guilds of riparian areas varied among parks and included woodland, riparian/wetland, and shrubland guilds as the most species-rich. The mixed guild dominance is likely driven by the varied riparian habitats present across parks, ranging from river floodplains to springs and seeps. These diverse riparian areas are important for breeders as well as migrants, but climate change likely will cause deterioration of CHDN riparian areas (Archer and Predick 2008). This deterioration can be expected to negatively impact birds that breed, feed, and migrate in these riparian areas.

Based on data and power analyses conducted for this report, the current CHDN landbird monitoring protocol has sufficient power to detect a 3% per year decline in species richness at the park-habitat level within about 15 years of monitoring, and to detect a 3% annual decline in occupancy within 20 to 30 years for species relatively widespread within a park-habitat (e.g., on average occurring at ≥75% of transects). However, these are likely species for which power to detect trends in density may also be adequate within the same time frame. An intended benefit of monitoring occupancy and density was the potential for occupancy to provide defensible information on changes in occurrence of less common species for which density analyses may be data limited. Unfortunately, with the current design's low number of transects within most park-habitats, detecting changes in occupancy of moderately uncommon species (~25% transect occupancy) may take 30 to 40 years. Detecting changes of relatively rare species (10% transect occupancy) may take more than 40 to 50 years at most park-habitats. To put this into context, a 3% annual loss over 40 years will result in a cumulative population decline of 70%. A 3% annual loss over 50 years translates to a population decline of 78%. Reallocating spatial effort—increasing the number of transects by 50 to 100% while reducing the number of points per transect—would have moderate benefits for detecting changes in occupancy, while allowing more analytical flexibility (e.g., for evaluating relationships between habitat condition and transect-level occupancy trends).

In CHDN monitoring to date, survey visits have occurred across a fairly wide window within the breeding season. Bird communities in network parks are highly dynamic within this survey window, as wintering birds and migrants may be captured in the early portion of the survey window and late breeders may be missed or undetected. Narrowing the seasonal window within which visits can occur from year to year would increase survey precision. Doing so would reduce the chances for confounding changes in survey timing with changes in the breeding bird community.

To date, the CHDN protocol has involved visits to each park-habitat every year. Reducing annual costs by visiting parks less frequently would lengthen the time frame for detecting moderate trends, particularly for occupancy. The potential insights gained from landbird monitoring would accrue with time, such that even less frequent visits would provide defensible trend information for CHDN bird communities with enough decades of monitoring. However, such a time frame for detecting changes in park resources is problematic given the urgency of current threats to CHDN parks from climate change and other factors.

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Appendix A. Landbird Sampling Locations in the Chihuahuan Desert Network.

Figures A-1 to A-6 contain maps of each Chihuahuan Desert Network park showing locations of landbird sampling transects and grids.

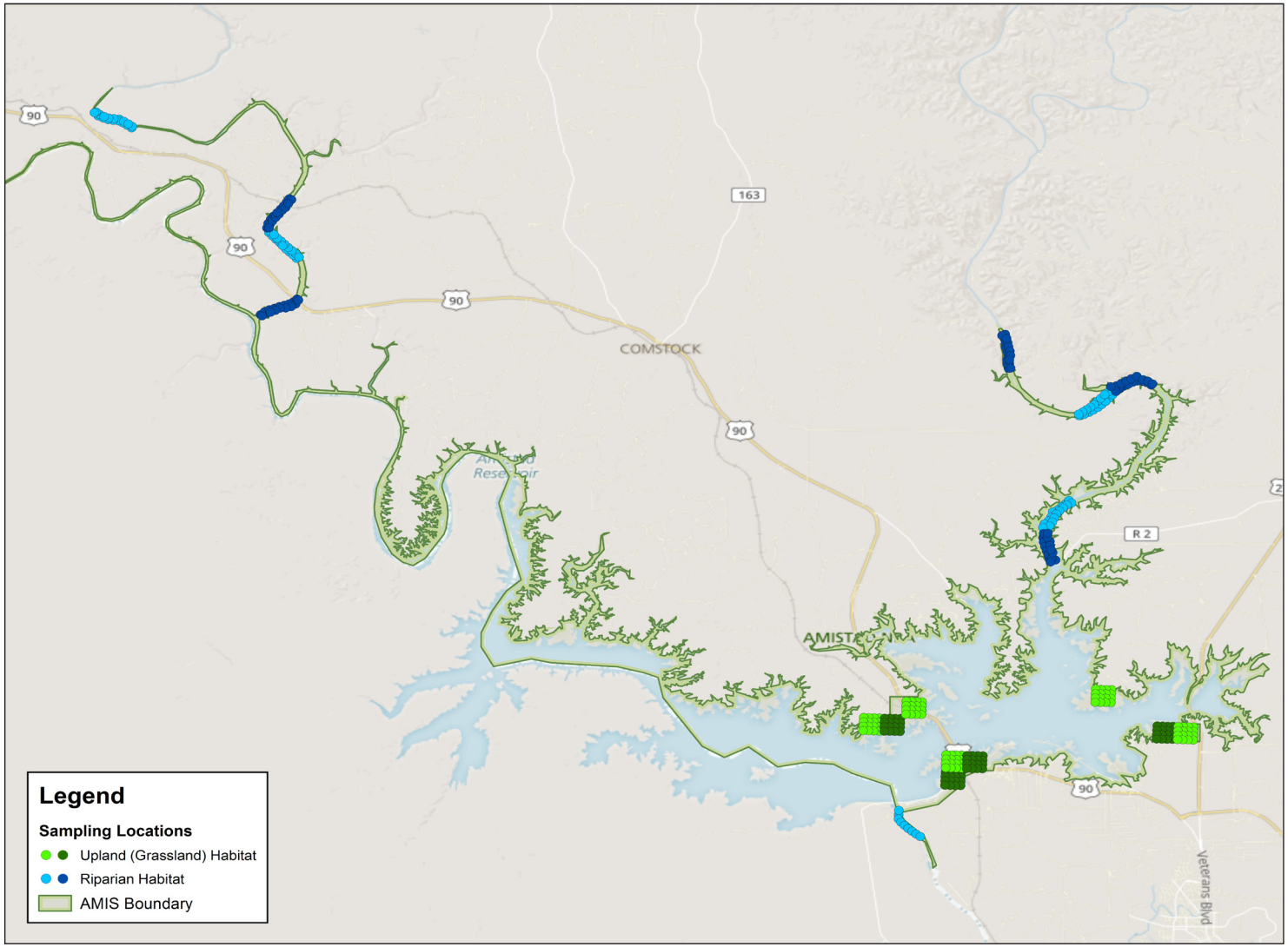


Figure A-1. Amistad National Recreation Area landbird sampling locations. Multiple shades of blue and green distinguish between adjacent grids or transects. Map base layer credit: NPS Park Tiles.

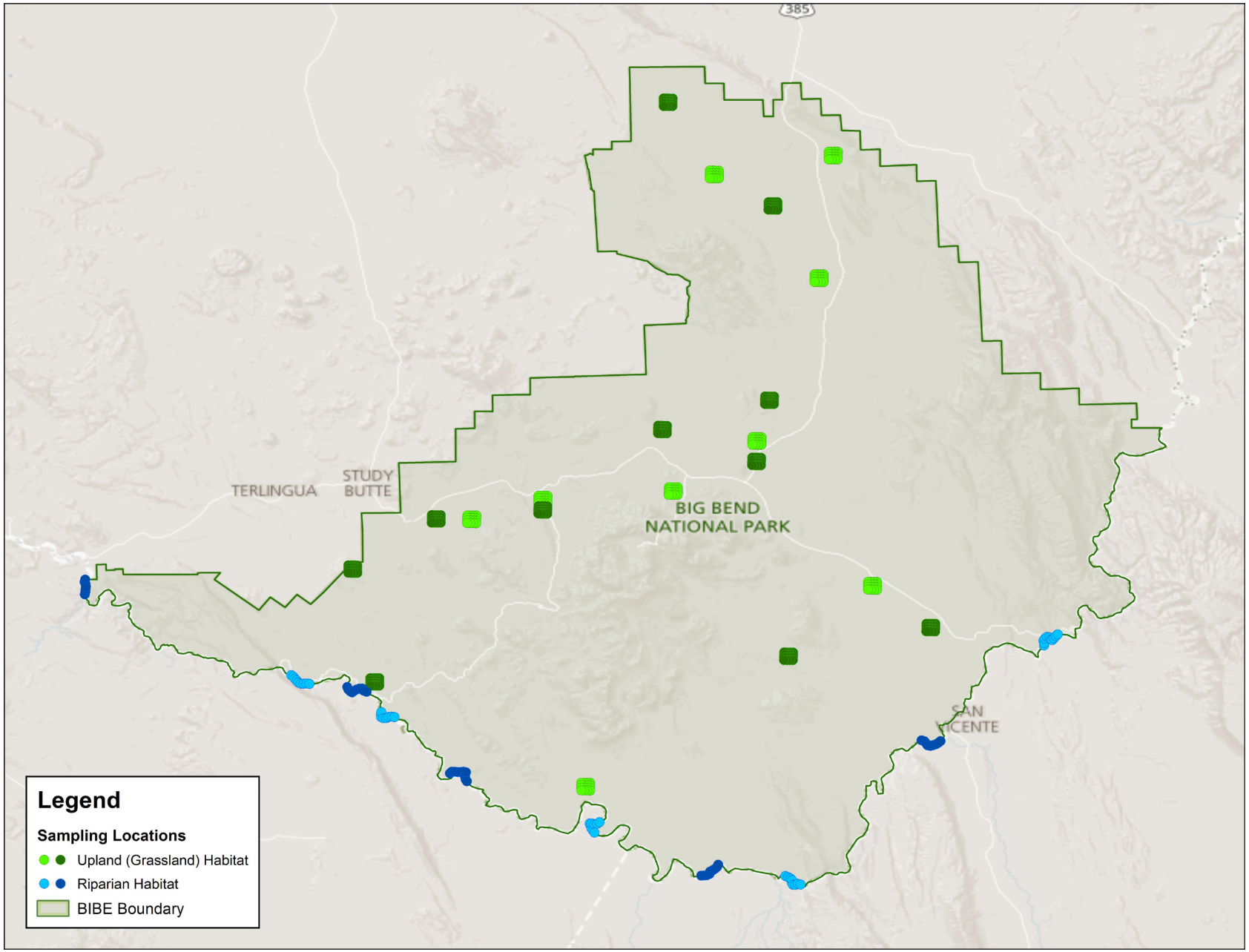


Figure A-2. Big Bend National Park landbird sampling locations. Multiple shades of blue and green distinguish between adjacent grids or transects. Map base layer credit: NPS Park Tiles.

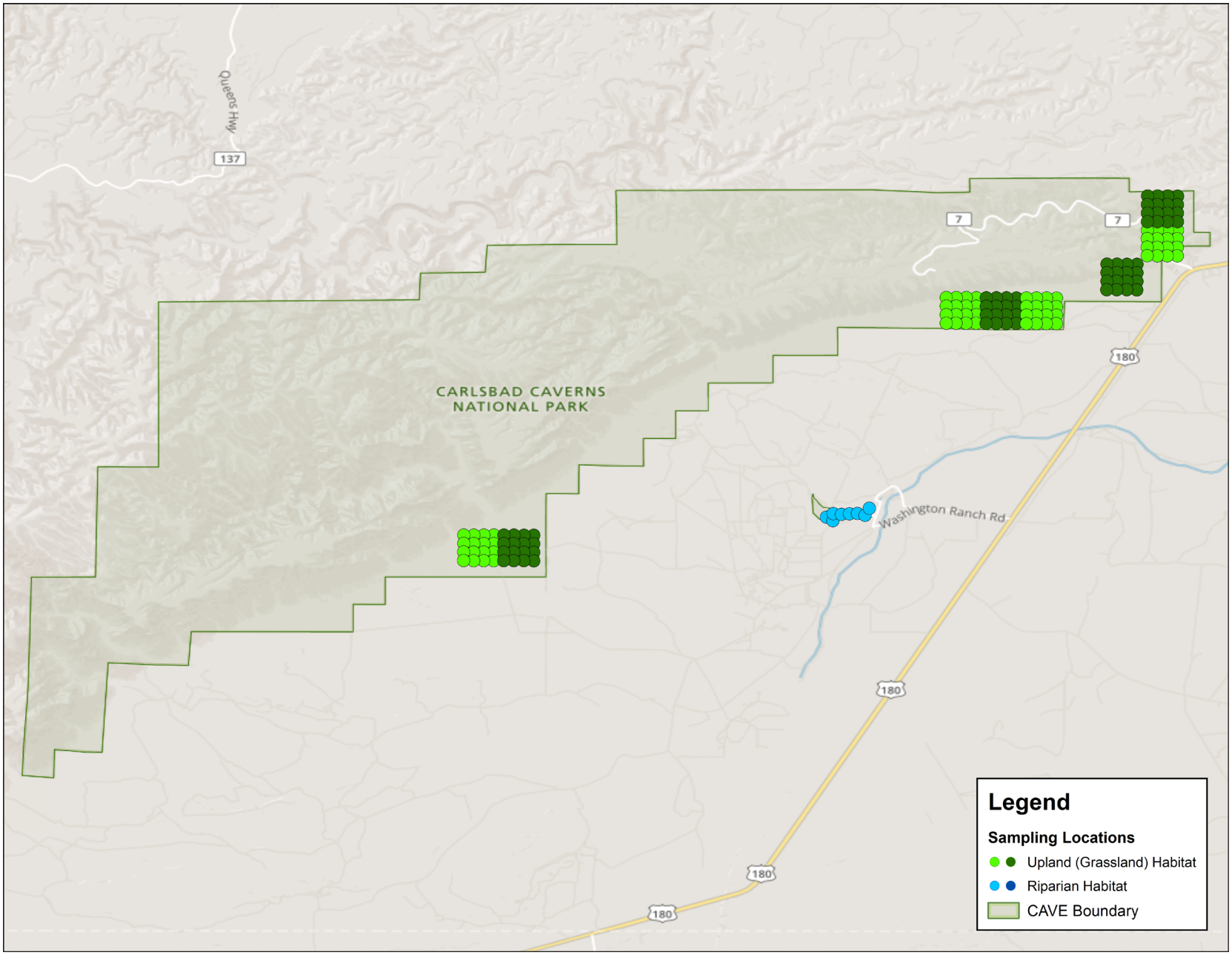


Figure A-3. Carlsbad Caverns National Park landbird sampling locations. Multiple shades of green distinguish between adjacent grids. Map base layer credit: NPS Park Tiles.

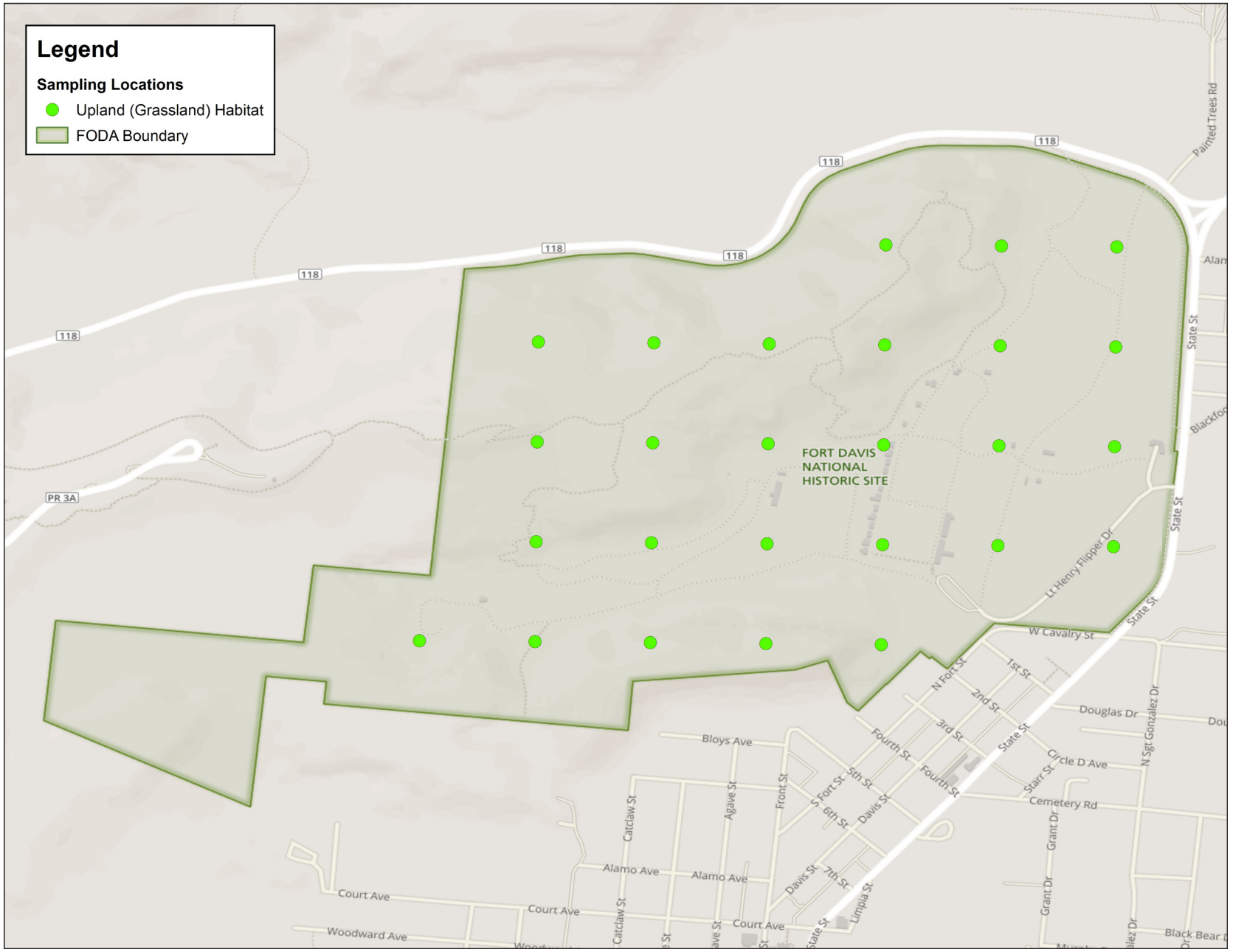


Figure A-4. Fort Davis National Historic Site landbird sampling locations. Map base layer credit: NPS Park Tiles.

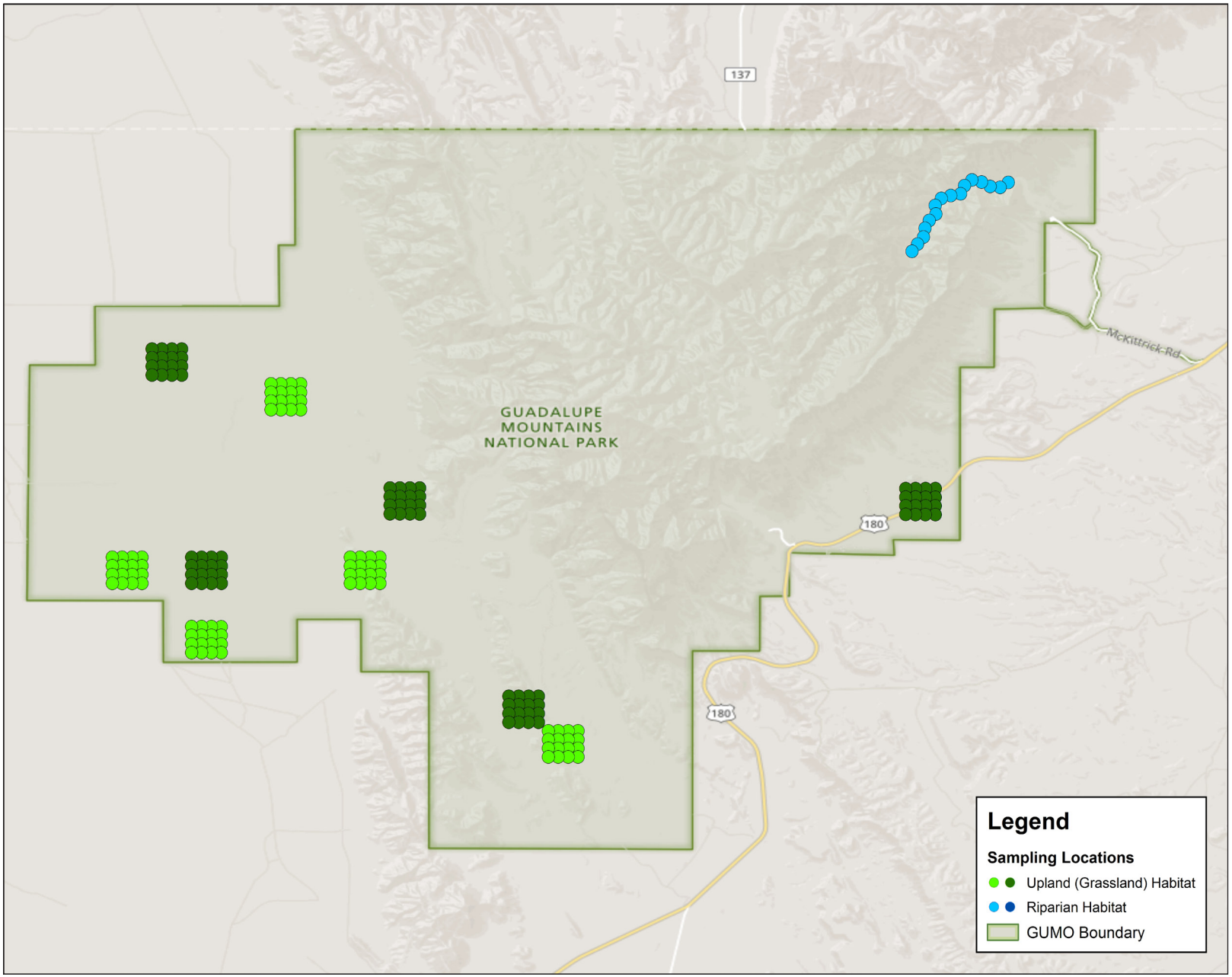


Figure A-5. Guadalupe Mountains National Park landbird sampling locations. Multiple shades of green distinguish between adjacent grids. Map base layer credit: NPS Park Tiles.

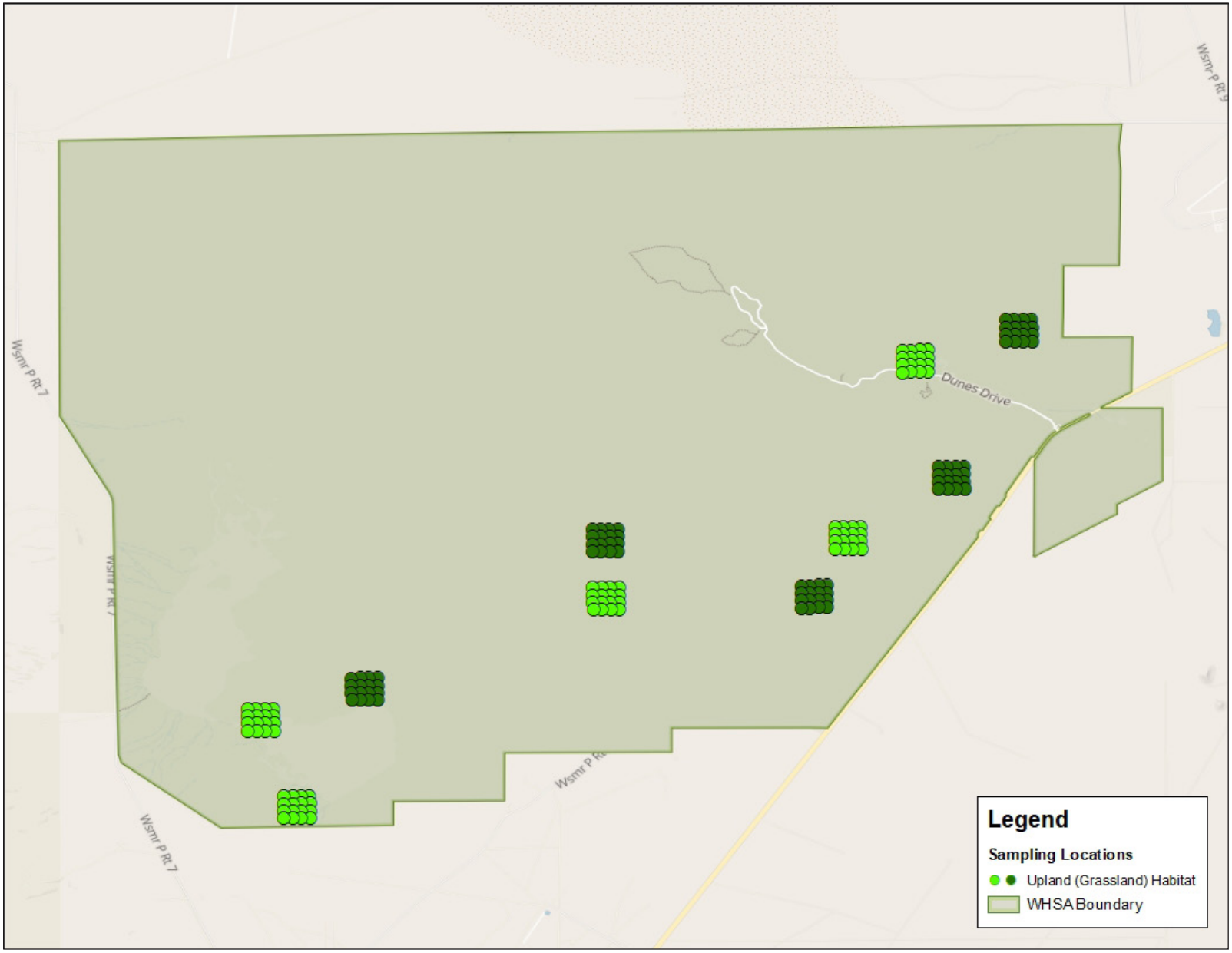


Figure A-6. White Sands National Park landbird sampling locations. Multiple shades of green distinguish between adjacent grids. Map base layer credit: NPS Park Tiles.

Appendix B. Bird Species in the Chihuahuan Desert Network.

Table B-1. Bird species occurring in the Chihuahuan Desert Network (CHDN) by park and whether they are known to breed (+) or not (o). List based on the NPS Southwest Network Collaboration database, 2019.

Common Name	Scientific Name	AMIS	BIBE	CAVE	FODA	GUMO	WHSA
Acadian Flycatcher	*Empidonax virescens*	o	–	–	–	–	–
Acorn Woodpecker	*Melanerpes formicivorus*	–	+	o [1]	+	+	o
American Avocet	*Recurvirostra americana*	o	o	o	–	–	+
American Bittern	*Botaurus lentiginosus*	o	o	o	–	–	–
American Coot	*Fulica americana*	+	+	o	–	o	+
American Crow	*Corvus brachyrhynchos*	o	–	o	–	–	o
American Dipper	*Cinclus mexicanus*	–	o	o	–	o	–
American Goldfinch	*Spinus tristis*	o	o	o	o	o	o
American Kestrel	*Falco sparverius*	+	+	+	+	+	+
American Pipit	*Anthus rubescens*	o	o	o	–	o	o
American Redstart	*Setophaga ruticilla*	o	o	o	–	o	o
American Robin	*Turdus migratorius*	o	o	o	o [1]	+	o
American Tree Sparrow	*Spizelloides arborea*	–	–	o	–	o	–
American White Pelican	*Pelecanus erythrorhynchos*	o	o	o	–	–	–
American Wigeon	*Mareca americana*	o	o	o	–	o	o
American Woodcock	*Scolopax minor*	–	o	o	–	–	–
Anhinga	*Anhinga anhinga*	o	o	–	–	–	–
Anna's Hummingbird	*Calypte anna*	o	o	o	o	o	–
Aplomado Falcon	*Falco femoralis*	–	o	–	–	o	–
Ash-throated Flycatcher	*Myiarchus cinerascens*	+	+	+	+	+	+
Aztec Thrush	*Ridgwayia pinicola*	–	o	–	–	–	–
Baird's Sandpiper	*Calidris bairdii*	o	o	o	–	–	o
Baird's Sparrow	*Centronyx bairdii*	–	o	o	–	–	o
Bald Eagle	*Haliaeetus leucocephalus*	o	o	o	–	o	o
Baltimore Oriole	*Icterus galbula*	o	o	o	–	o	–
Band-tailed Pigeon	*Patagioenas fasciata*	–	+	o	o	+	–
Bank Swallow	*Riparia riparia*	o	o	o	–	–	o
Barn Owl	*Tyto alba*	+	o [1]	+	–	o	+
Barn Swallow	*Hirundo rustica*	+	+	+	+	+	+
Bay-breasted Warbler	*Setophaga castanea*	–	o	o	–	–	–
Bell's Vireo	*Vireo bellii*	+	+	+	o [1]	o [1]	o
Belted Kingfisher	*Megaceryle alcyon*	o [1]	o	o	–	o [1]	o
Berylline Hummingbird	*Amazilia beryllina*	–	o	–	–	–	–
Bewick's Wren	*Thryomanes bewickii*	+	+	+	+	+	o
Black Phoebe	*Sayornis nigricans*	+	+	+	+	+	o
Black Swift	*Cypseloides niger*	–	–	–	–	o	–
Black Tern	*Chlidonias niger*	o	o	o	–	–	o
Black Vulture	*Coragyps atratus*	+	o [1]	o	–	o	–

[1] = Possible breeder; [2] = Historic breeder

Table B-1, cont. Bird species occurring in the CHDN by park and whether they are known to breed (+) or not (o).

Common Name	Scientific Name	AMIS	BIBE	CAVE	FODA	GUMO	WHSA
Black-and-white Warbler	*Mniotilta varia*	o	o	o	o	o	o
Black-bellied Plover	*Pluvialis squatarola*	o	–	–	–	–	o
Black-bellied Whistling-Duck	*Dendrocygna autumnalis*	o [1]	o	o	–	–	–
Black-billed Cuckoo	*Coccyzus erythropthalmus*	–	o	o	–	–	–
Black-billed Magpie	*Pica hudsonia*	–	–	o	–	–	–
Blackburnian Warbler	*Setophaga fusca*	–	o	o	–	–	–
Black-capped Vireo	*Vireo atricapilla*	+	+	o	–	–	–
Black-chinned Hummingbird	*Archilochus alexandri*	+	+	+	+	+	+
Black-chinned Sparrow	*Spizella atrogularis*	o	+	+	+	+	o
Black-crested Titmouse	*Baeolophus atricristatus*	+	+	–	+	o	–
Black-crowned Night-Heron	*Nycticorax nycticorax*	o	o [1]	o	–	–	o
Black-headed Grosbeak	*Pheucticus melanocephalus*	o	+	o [1]	o [1]	+	o
Black-legged Kittiwake	*Rissa tridactyla*	–	o	–	–	–	–
Black-necked Stilt	*Himantopus mexicanus*	+	o	o	–	–	+
Blackpoll Warbler	*Setophaga striata*	–	o	o	–	–	–
Black-tailed Gnatcatcher	*Polioptila melanura*	+	+	o [1]	+	+	+
Black-throated Blue Warbler	*Setophaga caerulescens*	o	o	o	–	o	o
Black-throated Gray Warbler	*Setophaga nigrescens*	–	o	o	–	+	o
Black-throated Green Warbler	*Setophaga virens*	–	o	o	–	o	–
Black-throated Sparrow	*Amphispiza bilineata*	+	+	+	+	+	+
Black-vented Oriole	*Icterus wagleri*	–	o	–	–	–	–
Blue Grosbeak	*Passerina caerulea*	+	+	+	+	+	+
Blue Jay	*Cyanocitta cristata*	o	o	o	–	o	–
Blue-gray Gnatcatcher	*Polioptila caerulea*	+	+	+	o	+	o
Blue-headed Vireo	*Vireo solitarius*	o	o	o	–	o	–
Blue-throated Mountain-gem	*Lampornis clemenciae*	–	+	o	–	+	–
Blue-winged Teal	*Spatula discors*	o	o	o	–	o	o
Blue-winged Warbler	*Vermivora cyanoptera*	–	o	o	o	–	–
Bobolink	*Dolichonyx oryzivorus*	o	o	o	–	–	–
Bonaparte's Gull	*Chroicocephalus philadelphia*	o	o	–	–	–	o
Brewer's Blackbird	*Euphagus cyanocephalus*	o	o	o	o	o	o
Brewer's Sparrow	*Spizella breweri*	o	o	o	o	o	o
Broad-billed Hummingbird	*Cynanthus latirostris*	–	o	o	–	o	–
Broad-tailed Hummingbird	*Selasphorus platycercus*	–	+	o [1]	o	+	o
Broad-winged Hawk	*Buteo platypterus*	–	o	o	–	–	–
Bronzed Cowbird	*Molothrus aeneus*	+	+	+	+	o [1]	+
Brown Creeper	*Certhia americana*	–	o	o	–	+	o
Brown Pelican	*Pelecanus occidentalis*	o	o	–	–	o	o
Brown Thrasher	*Toxostoma rufum*	o	o	o	–	o	o
Brown-crested Flycatcher	*Myiarchus tyrannulus*	o [1]	+	–	–	o	–
Brown-headed Cowbird	*Molothrus ater*	+	+	+	+	+	+

[1] = Possible breeder; [2] = Historic breeder

Table B-1, cont. Bird species occurring in the CHDN by park and whether they are known to breed (+) or not (o).

Common Name	Scientific Name	AMIS	BIBE	CAVE	FODA	GUMO	WHSA
Bufflehead	*Bucephala albeola*	o	o	o	–	o	o
Bullock's Oriole	*Icterus bullockii*	+	+	+	o	+	+
Burrowing Owl	*Athene cunicularia*	o	+	+	–	+	+
Bushtit	*Psaltriparus minimus*	o	+	+	+	+	–
Cactus Wren	*Campylorhynchus brunneicapillus*	+	+	+	+	+	+
California Gull	*Larus californicus*	o	–	–	–	–	–
Calliope Hummingbird	*Selasphorus calliope*	–	o	o	–	o	–
Canada Goose	*Branta canadensis*	o	o	o	–	o	o
Canada Warbler	*Cardellina canadensis*	–	o	o	–	–	–
Canvasback	*Aythya valisineria*	o	o	o	–	o	o
Canyon Towhee	*Melozone fusca*	+	+	+	+	+	+
Canyon Wren	*Catherpes mexicanus*	+	+	+	+	+	o
Cape May Warbler	*Setophaga tigrina*	–	o	o	–	–	–
Carolina Chickadee	*Poecile carolinensis*	o	–	–	–	–	–
Carolina Wren	*Thryothorus ludovicianus*	+	o [1]	o	–	o	–
Caspian Tern	*Hydroprogne caspia*	o	–	–	–	–	–
Cassin's Finch	*Haemorhous cassinii*	–	o	o	o	o	o
Cassin's Kingbird	*Tyrannus vociferans*	o	+	+	+	+	o
Cassin's Sparrow	*Peucaea cassinii*	+	+	+	+	+	+
Cassin's Vireo	*Vireo cassinii*	–	o	o	o	o	–
Cattle Egret	*Bubulcus ibis*	o	o	o	–	o	o
Cave Swallow	*Petrochelidon fulva*	+	+	+	+	o [1]	–
Cedar Waxwing	*Bombycilla cedrorum*	o	o	o	o	o	o
Cerulean Warbler	*Setophaga cerulea*	–	o	o	–	–	–
Chestnut-collared Longspur	*Calcarius ornatus*	o	o	o	–	o	o
Chestnut-sided Warbler	*Setophaga pensylvanica*	–	o	o	–	o	o
Chihuahuan Raven	*Corvus cryptoleucus*	+	o [2]	+	+	o	+
Chimney Swift	*Chaetura pelagica*	o [1]	o	o	–	–	–
Chipping Sparrow	*Spizella passerina*	o	o	o	o [1]	o	o
Cinnamon Teal	*Spatula cyanoptera*	o	o	o	–	o	o
Clark's Grebe	*Aechmophorus clarkii*	o	–	–	–	–	–
Clark's Nutcracker	*Nucifraga columbiana*	–	o	o	–	o	–
Clay-colored Sparrow	*Spizella pallida*	o	o	o	o	o	o
Clay-colored Thrush	*Turdus grayi*	–	o	–	–	–	–
Cliff Swallow	*Petrochelidon pyrrhonota*	+	+	+	+	+	o
Colima Warbler	*Leiothlypis crissalis*	–	+	–	–	o	–
Common Black Hawk	*Buteogallus anthracinus*	o [1]	+	+	o [1]	o [1]	–
Common Gallinule	*Gallinula galeata*	o	o	o	–	–	–
Common Goldeneye	*Bucephala clangula*	o	o	o	–	–	–
Common Grackle	*Quiscalus quiscula*	–	o	o	–	o	o
Common Ground Dove	*Columbina passerina*	+	+	o	–	–	–

[1] = Possible breeder; [2] = Historic breeder

Table B-1, cont. Bird species occurring in the CHDN by park and whether they are known to breed (+) or not (o).

Common Name	Scientific Name	AMIS	BIBE	CAVE	FODA	GUMO	WHSA
Common Loon	*Gavia immer*	o	o	–	–	–	o
Common Merganser	*Mergus merganser*	–	o	o	–	–	o
Common Nighthawk	*Chordeiles minor*	+	o[1]	+	o	+	o
Common Poorwill	*Phalaenoptilus nuttallii*	+	+	+	–	+	+
Common Raven	*Corvus corax*	+	+	o	+	+	o[1]
Common Yellowthroat	*Geothlypis trichas*	+	+	+	–	o	o
Connecticut Warbler	*Oporornis agilis*	–	–	o	–	–	–
Cooper's Hawk	*Accipiter cooperii*	o	+	+	+	+	o
Cordilleran Flycatcher	*Empidonax occidentalis*	–	+	+	o	+	o
Costa's Hummingbird	*Calypte costae*	–	o	–	–	–	–
Couch's Kingbird	*Tyrannus couchii*	o[1]	+	–	–	–	–
Crescent-chested Warbler	*Oreothlypis superciliosa*	–	o	–	–	–	–
Crested Caracara	*Caracara cheriway*	o[1]	o	–	–	–	–
Crissal Thrasher	*Toxostoma crissale*	–	+	+	–	+	+
Curve-billed Thrasher	*Toxostoma curvirostre*	+	+	+	+	+	+
Dark-eyed Junco	*Junco hyemalis*	–	o	o	o	+	o
Dickcissel	*Spiza americana*	o	o	o	–	o	o
Double-crested Cormorant	*Phalacrocorax auritus*	o[1]	o	o	–	–	–
Downy Woodpecker	*Dryobates pubescens*	–	–	o	–	o[1]	–
Dunlin	*Calidris alpina*	o	o	–	–	–	–
Dusky Flycatcher	*Empidonax oberholseri*	–	o	o	o	o[1]	o
Dusky-capped Flycatcher	*Myiarchus tuberculifer*	–	+	o	–	–	–
Eared Grebe	*Podiceps nigricollis*	o	o	o	–	–	o
Eastern Bluebird	*Sialia sialis*	o	+	+	o[1]	o	–
Eastern Kingbird	*Tyrannus tyrannus*	o	o	o	–	–	–
Eastern Meadowlark	*Sturnella magna*	+	o	+	+	+	+
Eastern Phoebe	*Sayornis phoebe*	o	o	o	–	+	–
Eastern Screech-Owl	*Megascops asio*	o[1]	+	–	–	–	–
Eastern Towhee	*Pipilo erythrophthalmus*	–	–	o	–	o	–
Eastern Wood-Pewee	*Contopus virens*	o	o	o	–	–	–
Elegant Trogon	*Trogon elegans*	–	o	–	–	–	–
Elf Owl	*Micrathene whitneyi*	o[1]	+	o	o[1]	+	–
Eurasian Collared-Dove	*Streptopelia decaocto*	+	+	+	+	+	+
Eurasian Wigeon	*Mareca penelope*	o	–	–	–	–	–
European Starling	*Sturnus vulgaris*	+	o	+	+	o	+
Evening Grosbeak	*Coccothraustes vespertinus*	–	o	o	–	o	o
Fan-tailed Warbler	*Basileuterus lachrymosus*	–	o	–	–	–	–
Ferruginous Hawk	*Buteo regalis*	o	o	o	o	o	o
Ferruginous Pygmy-Owl	*Glaucidium brasilianum*	–	o	–	–	–	–
Field Sparrow	*Spizella pusilla*	o[1]	o	o	o	o	–
Flame-colored Tanager	*Piranga bidentata*	–	o[1]	–	–	–	–

[1] = Possible breeder; [2] = Historic breeder

Table B-1, cont. Bird species occurring in the CHDN by park and whether they are known to breed (+) or not (o).

Common Name	Scientific Name	AMIS	BIBE	CAVE	FODA	GUMO	WHSA
Flammulated Owl	*Psiloscops flammeolus*	–	+	o	o	+	–
Forster's Tern	*Sterna forsteri*	o	o	o	–	–	o
Fox Sparrow	*Passerella iliaca*	o	o	o	–	o	–
Franklin's Gull	*Leucophaeus pipixcan*	o	o	o	–	–	o
Gadwall	*Mareca strepera*	o	o	o	–	o	o
Gambel's Quail	*Callipepla gambelii*	–	o	–	–	o	+
Golden Eagle	*Aquila chrysaetos*	o	o[2]	+	o	+	o
Golden-cheeked Warbler	*Setophaga chrysoparia*	–	o	–	–	–	–
Golden-crowned Kinglet	*Regulus satrapa*	o	o	o	–	o	–
Golden-crowned Sparrow	*Zonotrichia atricapilla*	–	o	o	–	o	–
Golden-fronted Woodpecker	*Melanerpes aurifrons*	+	+	–	–	–	–
Golden-winged Warbler	*Vermivora chrysoptera*	–	o	o	–	–	–
Grace's Warbler	*Setophaga graciae*	–	o	o	–	+	–
Grasshopper Sparrow	*Ammodramus savannarum*	o	o	o	o	o	–
Gray Catbird	*Dumetella carolinensis*	o	o	o	–	o	o
Gray Flycatcher	*Empidonax wrightii*	–	o	+	o	+	o
Gray Hawk	*Buteo plagiatus*	–	+	+	o[1]	–	–
Gray Vireo	*Vireo vicinior*	o	+	+	–	+	o
Gray-cheeked Thrush	*Catharus minimus*	–	o	o	–	–	o
Great Blue Heron	*Ardea herodias*	+	o[1]	o	o	o	o
Great Crested Flycatcher	*Myiarchus crinitus*	o	o	o	–	–	–
Great Egret	*Ardea alba*	o	o	o	–	o	o
Great Horned Owl	*Bubo virginianus*	+	+	+	+	+	+
Great Kiskadee	*Pitangus sulphuratus*	o[1]	o	o	–	–	–
Greater Pewee	*Contopus pertinax*	–	o	o	–	o	–
Greater Roadrunner	*Geococcyx californianus*	+	+	+	+	+	+
Greater White-fronted Goose	*Anser albifrons*	o	o	–	–	–	–
Greater Yellowlegs	*Tringa melanoleuca*	o	o	o	–	–	o
Great-tailed Grackle	*Quiscalus mexicanus*	+	o[1]	+	+	o[1]	+
Green Heron	*Butorides virescens*	o[1]	+	o	–	–	o
Green Jay	*Cyanocorax yncas*	o	–	–	–	–	–
Green Kingfisher	*Chloroceryle americana*	o[1]	o	–	–	–	–
Green-tailed Towhee	*Pipilo chlorurus*	o	o	o	o	o[2]	o
Green-winged Teal	*Anas crecca*	o	o	o	–	o	o
Groove-billed Ani	*Crotophaga sulcirostris*	o	+	o	–	–	–
Gull-billed Tern	*Gelochelidon nilotica*	o	–	–	–	–	–
Hairy Woodpecker	*Dryobates villosus*	–	–	o	–	+	–
Hammond's Flycatcher	*Empidonax hammondii*	–	o	o	–	o	–
Harris's Hawk	*Parabuteo unicinctus*	o	o[2]	o	o	o	o
Harris's Sparrow	*Zonotrichia querula*	–	o	o	–	–	o
Hepatic Tanager	*Piranga flava*	–	+	+	o[1]	+	o
Hermit Thrush	*Catharus guttatus*	o	o	o	o	+	o

[1] = Possible breeder; [2] = Historic breeder

Table B-1, cont. Bird species occurring in the CHDN by park and whether they are known to breed (+) or not (o).

Common Name	Scientific Name	AMIS	BIBE	CAVE	FODA	GUMO	WHSA
Hermit Warbler	*Setophaga occidentalis*	–	o	o	–	o	–
Herring Gull	*Larus argentatus*	o	–	–	–	o	–
Hooded Merganser	*Lophodytes cucullatus*	o	o	o	–	–	–
Hooded Oriole	*Icterus cucullatus*	+	+	+	–	o	o
Hooded Warbler	*Setophaga citrina*	–	o	o	–	o	o
Horned Grebe	*Podiceps auritus*	o	–	–	–	–	o
Horned Lark	*Eremophila alpestris*	+	o	o[1]	o	o	+
House Finch	*Haemorhous mexicanus*	+	+	+	+	+	+
House Sparrow	*Passer domesticus*	+	+	+	+	+	+
House Wren	*Troglodytes aedon*	o	o	o	o	+	o
Hutton's Vireo	*Vireo huttoni*	–	+	o	o	+	–
Inca Dove	*Columbina inca*	+	+	o	o	o	+
Indigo Bunting	*Passerina cyanea*	o[1]	o	+	o	o[1]	o
Juniper Titmouse	*Baeolophus ridgwayi*	–	–	o[1]	–	+	–
Kentucky Warbler	*Geothlypis formosa*	–	o	o	–	o	o
Killdeer	*Charadrius vociferus*	+	+	+	+	+	+
King Rail	*Rallus elegans*	–	o	–	–	–	–
Ladder-backed Woodpecker	*Dryobates scalaris*	+	+	+	+	+	+
Lark Bunting	*Calamospiza melanocorys*	o	o	o	o	o	o
Lark Sparrow	*Chondestes grammacus*	+	o	+	+	+	o
Laughing Gull	*Leucophaeus atricilla*	o	o	–	–	–	–
Lawrence's Goldfinch	*Spinus lawrencei*	–	–	–	–	o	–
Lazuli Bunting	*Passerina amoena*	–	o	o	–	o	o
LeConte's Sparrow	*Ammospiza leconteii*	o	o	o	–	–	–
Least Bittern	*Ixobrychus exilis*	–	o	o	–	–	–
Least Flycatcher	*Empidonax minimus*	o	o	o	–	o	–
Least Grebe	*Tachybaptus dominicus*	o[1]	o	–	–	–	–
Least Sandpiper	*Calidris minutilla*	o	o	o	–	–	o
Least Tern	*Sternula antillarum*	+	o	–	–	–	o
Lesser Black-backed Gull	*Larus fuscus*	o	–	–	–	–	–
Lesser Goldfinch	*Spinus psaltria*	+	+	+	+	+	o[1]
Lesser Nighthawk	*Chordeiles acutipennis*	+	+	+	o	+	+
Lesser Prairie-Chicken	*Tympanuchus pallidicinctus*	–	–	o	–	–	–
Lesser Scaup	*Aythya affinis*	o	o	o	–	o	o
Lesser Yellowlegs	*Tringa flavipes*	o	o	o	–	–	–
Lewis's Woodpecker	*Melanerpes lewis*	–	o	o	–	o	–
Lincoln's Sparrow	*Melospiza lincolnii*	o	o	o	o	o	o
Little Blue Heron	*Egretta caerulea*	o	o	–	–	–	–
Loggerhead Shrike	*Lanius ludovicianus*	+	+	+	+	+	+
Long-billed Curlew	*Numenius americanus*	o	o	o	–	o	o
Long-billed Dowitcher	*Limnodromus scolopaceus*	o	o	o	–	–	o

[1] = Possible breeder; [2] = Historic breeder

Table B-1, cont. Bird species occurring in the CHDN by park and whether they are known to breed (+) or not (o).

Common Name	Scientific Name	AMIS	BIBE	CAVE	FODA	GUMO	WHSA
Long-billed Thrasher	*Toxostoma longirostre*	o [1]	o	o	–	–	–
Long-eared Owl	*Asio otus*	–	o	o	–	o	–
Louisiana Waterthrush	*Parkesia motacilla*	–	o	o	–	–	–
Lucifer Hummingbird	*Calothorax lucifer*	–	+	o	–	o	–
Lucy's Warbler	*Leiothlypis luciae*	o	+	+	–	–	o
MacGillivray's Warbler	*Geothlypis tolmiei*	o	o	o	o	o	o
Magnolia Warbler	*Setophaga magnolia*	–	o	o	–	–	–
Mallard	*Anas platyrhynchos*	+	+	o	o	o	o
Marbled Godwit	*Limosa fedoa*	–	–	–	–	–	o
Marsh Wren	*Cistothorus palustris*	o	o	o	–	o	o
McCown's Longspur	*Rhynchophanes mccownii*	o	–	o	–	o	–
Merlin	*Falco columbarius*	o	o	o	–	o	o
Mexican Jay	*Aphelocoma wollweberi*	–	+	–	–	–	–
Mexican Whip-poor-will	*Antrostomus arizonae*	–	+	o	–	+	–
Mississippi Kite	*Ictinia mississippiensis*	o	o	o	–	–	–
Montezuma Quail	*Cyrtonyx montezumae*	–	o [2]	o [2]	+	o [2]	–
Morelet's Seedeater	*Sporophila morelleti*	o	–	–	–	–	–
Mountain Bluebird	*Sialia currucoides*	o	o	o	o	o	o
Mountain Chickadee	*Poecile gambeli*	–	o	o	–	+	o
Mourning Dove	*Zenaida macroura*	+	+	+	+	+	+
Mourning Warbler	*Geothlypis philadelphia*	–	o	–	–	–	–
Nashville Warbler	*Leiothlypis ruficapilla*	o	o	o	–	o	o
Neotropic Cormorant	*Phalacrocorax brasilianus*	+	o	o	–	–	–
Northern Beardless-Tyrannulet	*Camptostoma imberbe*	–	–	o	–	–	–
Northern Bobwhite	*Colinus virginianus*	+	–	o	–	o	–
Northern Cardinal	*Cardinalis cardinalis*	+	+	+	+	o [1]	o
Northern Flicker	*Colaptes auratus*	o	+	o	o	+	o
Northern Goshawk	*Accipiter gentilis*	–	o	o	–	o	–
Northern Harrier	*Circus hudsonius*	o	o	o	o	o	o
Northern Mockingbird	*Mimus polyglottos*	+	+	+	+	+	+
Northern Parula	*Setophaga americana*	–	o	o	–	o	o
Northern Pintail	*Anas acuta*	o	o	o	–	–	o
Northern Pygmy-Owl	*Glaucidium gnoma*	–	o	o	–	o	–
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	+	+	o	–	o	o
Northern Saw-whet Owl	*Aegolius acadicus*	–	o	–	–	+	–
Northern Shoveler	*Spatula clypeata*	o	o	o	–	o	o
Northern Shrike	*Lanius borealis*	–	–	–	–	o	–
Northern Waterthrush	*Parkesia noveboracensis*	–	o	o	–	o	o
Nutting's Flycatcher	*Myiarchus nuttingi*	–	o	–	–	–	–
Olive Sparrow	*Arremonops rufivirgatus*	o [1]	–	–	–	–	–
Olive Warbler	*Peucedramus taeniatus*	–	o	–	–	–	–

[1] = Possible breeder; [2] = Historic breeder

Table B-1, cont. Bird species occurring in the CHDN by park and whether they are known to breed (+) or not (o).

Common Name	Scientific Name	AMIS	BIBE	CAVE	FODA	GUMO	WHSA
Olive-sided Flycatcher	*Contopus cooperi*	o	o	o	o	+	o
Orange-crowned Warbler	*Leiothlypis celata*	o	o	o	o	+	o
Orchard Oriole	*Icterus spurius*	+	+	+	o[1]	o	o
Osprey	*Pandion haliaetus*	+	o	o	–	o	–
Ovenbird	*Seiurus aurocapilla*	–	o	o	–	o	o
Pacific Loon	*Gavia pacifica*	o	–	–	–	–	–
Pacific Wren	*Troglodytes pacificus*	–	–	o	–	–	–
Pacific-slope Flycatcher	*Empidonax difficilis*	–	–	–	–	o	–
Painted Bunting	*Passerina ciris*	+	+	+	o[1]	o	o
Painted Redstart	*Myioborus pictus*	–	+	o	–	o	–
Palm Warbler	*Setophaga palmarum*	–	o	o	–	–	o
Pectoral Sandpiper	*Calidris melanotos*	o	o	–	–	–	–
Peregrine Falcon	*Falco peregrinus*	o	+	o[1]	–	+	o
Phainopepla	*Phainopepla nitens*	o	+	+	+	+	+
Philadelphia Vireo	*Vireo philadelphicus*	–	o	o	–	–	–
Pied-billed Grebe	*Podilymbus podiceps*	+	+	o	–	o	o
Pine Grosbeak	*Pinicola enucleator*	–	–	–	–	o	–
Pine Siskin	*Spinus pinus*	o	o	o	o	+	o
Pine Warbler	*Setophaga pinus*	–	o	o	–	o	–
Pinyon Jay	*Gymnorhinus cyanocephalus*	–	o	o	–	o	–
Piratic Flycatcher	*Legatus leucophaius*	–	o	o	–	–	–
Plain-capped Starthroat	*Heliomaster constantii*	–	–	–	–	–	o
Plumbeous Vireo	*Vireo plumbeus*	o	o[1]	+	o	+	o
Prairie Falcon	*Falco mexicanus*	o	o[1]	o[1]	o[1]	+	o
Prairie Warbler	*Setophaga discolor*	–	o	o	–	–	–
Prothonotary Warbler	*Protonotaria citrea*	–	o	o	–	–	–
Purple Finch	*Haemorhous purpureus*	–	o	o	–	o	–
Purple Gallinule	*Porphyrio martinicus*	–	o	–	–	–	–
Purple Martin	*Progne subis*	+	o	o	–	o	o
Pygmy Nuthatch	*Sitta pygmaea*	–	o	o	–	+	–
Pyrrhuloxia	*Cardinalis sinuatus*	+	+	+	+	+	+
Red Crossbill	*Loxia curvirostra*	–	o	o	–	+	–
Red-bellied Woodpecker	*Melanerpes carolinus*	–	–	o	–	–	–
Red-breasted Merganser	*Mergus serrator*	o	o	–	–	–	–
Red-breasted Nuthatch	*Sitta canadensis*	–	o	o	o	+	o
Reddish Egret	*Egretta rufescens*	o	o	–	–	–	–
Red-eyed Vireo	*Vireo olivaceus*	–	o	o	–	o	o
Red-faced Warbler	*Cardellina rubrifrons*	–	o	–	–	o	–
Redhead	*Aythya americana*	o	o	o	–	o	o
Red-headed Woodpecker	*Melanerpes erythrocephalus*	–	o	o	–	o	o
Red-naped Sapsucker	*Sphyrapicus nuchalis*	–	o	o	–	o	o
Red-necked Phalarope	*Phalaropus lobatus*	–	–	o	–	–	o

[1] = Possible breeder; [2] = Historic breeder

Table B-1, cont. Bird species occurring in the CHDN by park and whether they are known to breed (+) or not (o).

Common Name	Scientific Name	AMIS	BIBE	CAVE	FODA	GUMO	WHSA
Red-shouldered Hawk	*Buteo lineatus*	o	+	o	–	–	–
Red-tailed Hawk	*Buteo jamaicensis*	+	+	+	+	+	+
Red-winged Blackbird	*Agelaius phoeniceus*	+	o	+	–	+	o
Ring-billed Gull	*Larus delawarensis*	o	o	o	–	o	o
Ringed Kingfisher	*Megaceryle torquata*	o [1]	–	–	–	–	–
Ring-necked Duck	*Aythya collaris*	o	o	o	–	o	o
Ring-necked Pheasant	*Phasianus colchicus*	o	–	o	–	o	–
Rivoli's Hummingbird	*Eugenes fulgens*	–	+	o	–	+	–
Rock Pigeon	*Columba livia*	+	o	o	o [1]	o	+
Rock Wren	*Salpinctes obsoletus*	+	+	+	+	+	o
Roseate Spoonbill	*Platalea ajaja*	o	o	–	–	–	–
Rose-breasted Grosbeak	*Pheucticus ludovicianus*	–	o	o	–	o	o
Rose-throated Becard	*Pachyramphus aglaiae*	–	o	–	–	–	–
Ross's Goose	*Anser rossii*	–	o	o	–	–	–
Rough-legged Hawk	*Buteo lagopus*	–	o	o	–	o	o
Royal Tern	*Thalasseus maximus*	o	–	–	–	–	–
Ruby-crowned Kinglet	*Regulus calendula*	o	o	o	o	o	o
Ruby-throated Hummingbird	*Archilochus colubris*	o	o	o	–	o	–
Ruddy Duck	*Oxyura jamaicensis*	o	o	o	–	o	o
Ruddy Ground Dove	*Columbina talpacoti*	–	o	o	–	–	–
Rufous Hummingbird	*Selasphorus rufus*	–	o	o	o	o	o
Rufous-backed Robin	*Turdus rufopalliatus*	–	o	–	–	–	–
Rufous-capped Warbler	*Basileuterus rufifrons*	o	o	–	–	–	–
Rufous-crowned Sparrow	*Aimophila ruficeps*	+	+	+	+	+	+
Rusty Blackbird	*Euphagus carolinus*	–	o	o	–	–	–
Sage Thrasher	*Oreoscoptes montanus*	o	o	o	o	o	o
Sagebrush Sparrow	*Artemisiospiza nevadensis*	–	o	o	–	o	o
Sandhill Crane	*Antigone canadensis*	o	o	o	–	o	o
Savannah Sparrow	*Passerculus sandwichensis*	o	o	o	o	o	o
Say's Phoebe	*Sayornis saya*	+	+	+	+	+	+
Scaled Quail	*Callipepla squamata*	+	+	+	+	+	+
Scarlet Tanager	*Piranga olivacea*	–	o	o	–	o	o
Scissor-tailed Flycatcher	*Tyrannus forficatus*	+	o	o [1]	–	o	o
Scott's Oriole	*Icterus parisorum*	+	+	+	+	+	+
Sedge Wren	*Cistothorus platensis*	o	o	o	–	–	–
Semipalmated Plover	*Charadrius semipalmatus*	o	–	–	–	–	o
Semipalmated Sandpiper	*Calidris pusilla*	o	–	o	–	–	o
Sharp-shinned Hawk	*Accipiter striatus*	o	o	o	o	+	o
Shiny Cowbird	*Molothrus bonariensis*	–	–	o	–	–	–
Short-eared Owl	*Asio flammeus*	–	o	o	–	–	–
Short-tailed Hawk	*Buteo brachyurus*	–	o	o	–	–	–

[1] = Possible breeder; [2] = Historic breeder

Table B-1, cont. Bird species occurring in the CHDN by park and whether they are known to breed (+) or not (o).

Common Name	Scientific Name	AMIS	BIBE	CAVE	FODA	GUMO	WHSA
Slate-throated Redstart	*Myioborus miniatus*	–	o	–	–	–	–
Smith's Longspur	*Calcarius pictus*	–	o	–	–	–	–
Snow Bunting	*Plectrophenax nivalis*	–	o	–	–	–	–
Snow Goose	*Anser caerulescens*	o	o	o	–	o	o
Snowy Egret	*Egretta thula*	o	o	o	–	o	o
Snowy Plover	*Charadrius nivosus*	+	–	–	–	–	+
Solitary Sandpiper	*Tringa solitaria*	o	o	o	–	–	o
Song Sparrow	*Melospiza melodia*	+	o	o	o	o	o
Sora	*Porzana carolina*	o	o	o	–	–	o
Spotted Owl (Mexican)	*Strix occidentalis (lucida)*	–	–	o[1]	–	+	–
Spotted Sandpiper	*Actitis macularius*	o	o	o	–	o	o
Spotted Towhee	*Pipilo maculatus*	o	+	o	o	+	o
Sprague's Pipit	*Anthus spragueii*	o	o	o	–	–	–
Steller's Jay	*Cyanocitta stelleri*	–	o	o	o	+	o
Stilt Sandpiper	*Calidris himantopus*	o	–	–	–	–	o
Streak-backed Oriole	*Icterus pustulatus*	–	–	o	–	–	–
Sulphur-bellied Flycatcher	*Myiodynastes luteiventris*	–	o	–	–	–	–
Summer Tanager	*Piranga rubra*	+	+	+	+	+	o
Swainson's Hawk	*Buteo swainsoni*	+	+	+	+	+	+
Swainson's Thrush	*Catharus ustulatus*	o	o	o	–	o	o
Swainson's Warbler	*Limnothlypis swainsonii*	–	o	o	–	–	–
Swallow-tailed Kite	*Elanoides forficatus*	–	o	–	o	–	–
Swamp Sparrow	*Melospiza georgiana*	o	o	o	o	o	–
Tennessee Warbler	*Leiothlypis peregrina*	o	o	o	–	–	o
Thick-billed Kingbird	*Tyrannus crassirostris*	–	+	o	–	–	–
Townsend's Solitaire	*Myadestes townsendi*	–	o	o	o	o	o
Townsend's Warbler	*Setophaga townsendi*	o	o	o	o	o	o
Tree Swallow	*Tachycineta bicolor*	o	o	o	o	–	o
Tricolored Heron	*Egretta tricolor*	o	o	o	–	–	–
Tropical Kingbird	*Tyrannus melancholicus*	–	+	–	–	–	–
Tropical Parula	*Setophaga pitiayumi*	–	o	–	–	–	–
Tufted Flycatcher	*Mitrephanes phaeocercus*	–	o	–	–	–	–
Tundra Swan	*Cygnus columbianus*	–	o	o	–	–	–
Turkey Vulture	*Cathartes aura*	+	+	+	+	+	o[1]
Upland Sandpiper	*Bartramia longicauda*	o	o	o	–	o	–
Varied Bunting	*Passerina versicolor*	+	+	+	o	o[2]	–
Varied Thrush	*Ixoreus naevius*	–	o	o	–	o	–
Veery	*Catharus fuscescens*	–	o	–	–	–	–
Verdin	*Auriparus flaviceps*	+	+	+	+	+	+
Vermilion Flycatcher	*Pyrocephalus rubinus*	+	+	+	+	o[1]	+
Vesper Sparrow	*Pooecetes gramineus*	o	o	o	o	o	o

[1] = Possible breeder; [2] = Historic breeder

Table B-1, cont. Bird species occurring in the CHDN by park and whether they are known to breed (+) or not (o).

Common Name	Scientific Name	AMIS	BIBE	CAVE	FODA	GUMO	WHSA
Violet-crowned Hummingbird	*Amazilia violiceps*	o	o	–	–	–	–
Violet-green Swallow	*Tachycineta thalassina*	–	+	o	o	+	o
Virginia Rail	*Rallus limicola*	o	o	o	–	–	o[2]
Virginia's Warbler	*Leiothlypis virginiae*	–	o	o	o	+	o
Warbling Vireo	*Vireo gilvus*	o	+	o[1]	o[2]	+	o
Western Bluebird	*Sialia mexicana*	–	o	+	o	+	o
Western Grebe	*Aechmophorus occidentalis*	o	–	o	–	–	o
Western Kingbird	*Tyrannus verticalis*	+	+	+	+	+	+
Western Meadowlark	*Sturnella neglecta*	o[1]	o	o	o	o[1]	+
Western Sandpiper	*Calidris mauri*	o	o	o	–	o	o
Western Screech-Owl	*Megascops kennicottii*	o	+	o[1]	o[1]	+	o
Western Tanager	*Piranga ludoviciana*	o	o[1]	o[1]	o	+	o
Western Wood-Pewee	*Contopus sordidulus*	–	o[1]	+	o	+	+
Whimbrel	*Numenius phaeopus*	–	o	–	–	–	–
White Ibis	*Eudocimus albus*	o	o	o	–	–	–
White-breasted Nuthatch	*Sitta carolinensis*	–	+	o[1]	o	+	–
White-crowned Sparrow	*Zonotrichia leucophrys*	o	o	o	o	o	o
White-eared Hummingbird	*Hylocharis leucotis*	–	o	–	–	o	–
White-eyed Vireo	*Vireo griseus*	o	o	o	–	o	–
White-faced Ibis	*Plegadis chihi*	o	o	o	–	–	o
White-tailed Hawk	*Geranoaetus albicaudatus*	–	o	–	–	–	–
White-tailed Kite	*Elanus leucurus*	o	o	o	–	–	–
White-throated Sparrow	*Zonotrichia albicollis*	–	o	o	o	o	o
White-throated Swift	*Aeronautes saxatalis*	+	+	+	+	+	o
White-tipped Dove	*Leptotila verreauxi*	o[1]	o	–	–	–	–
White-winged Dove	*Zenaida asiatica*	+	+	+	+	+	+
Wild Turkey	*Meleagris gallopavo*	+	o[1]	+	–	+	–
Willet	*Tringa semipalmata*	o	o	o	–	o	o
Williamson's Sapsucker	*Sphyrapicus thyroideus*	–	o	o	–	o	o
Willow Flycatcher	*Empidonax traillii*	–	o	+	–	o	–
Wilson's Phalarope	*Phalaropus tricolor*	o	o	o	–	–	o
Wilson's Snipe	*Gallinago delicata*	o	o	o	–	o	o
Wilson's Warbler	*Cardellina pusilla*	o	o	o	o	o	o
Winter Wren	*Troglodytes hiemalis*	o	o	o	–	o	–
Wood Duck	*Aix sponsa*	o[1]	+	o	–	o	–
Wood Thrush	*Hylocichla mustelina*	–	o	o	–	–	o
Woodhouse's Scrub-Jay	*Aphelocoma woodhouseii*	o	o	o[1]	+	+	o
Worm-eating Warbler	*Helmitheros vermivorum*	o	o	o	–	o	o
Yellow Rail	*Coturnicops noveboracensis*	–	o	–	–	–	–
Yellow Warbler	*Setophaga petechia*	o	o[2]	+	o	o	o
Yellow-bellied Flycatcher	*Empidonax flaviventris*	–	o	o	–	–	–

[1] = Possible breeder; [2] = Historic breeder

Table B-1, cont. Bird species occurring in the CHDN by park and whether they are known to breed (+) or not (o).

Common Name	Scientific Name	AMIS	BIBE	CAVE	FODA	GUMO	WHSA
Yellow-bellied Sapsucker	*Sphyrapicus varius*	o	o	o	–	o	–
Yellow-billed Cuckoo	*Coccyzus americanus*	+	+	+	o [1]	+	–
Yellow-breasted Chat	*Icteria virens*	+	+	+	o [1]	+	o
Yellow-crowned Night-Heron	*Nyctanassa violacea*	o	o	o	–	–	–
Yellow-eyed Junco	*Junco phaeonotus*	–	o	–	–	o	–
Yellow-green Vireo	*Vireo flavoviridis*	–	o	o	–	–	–
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	o	o	o	o	o	o
Yellow-rumped Warbler	*Setophaga coronata*	o	o	o	o	+	o
Yellow-throated Vireo	*Vireo flavifrons*	o	o	o	–	o	–
Yellow-throated Warbler	*Setophaga dominica*	o	o	o	–	–	o
Zone-tailed Hawk	*Buteo albonotatus*	o	+	o	o	o [1]	–

Symbols and Notes:

+ = Species has been recorded breeding within the park.

o = Species has not been recorded breeding within the park.

[1] = Possible breeder

[2] = Historic breeder

Park codes: AMIS = Amistad NRA; BIBE = Big Bend NP; CAVE = Carlsbad Caverns NP; FODA = Fort Davis NHS; GUMO = Guadalupe Mountains NP; WHSA = White Sands NP.

Common and scientific bird names follow the Sixtieth Supplement to the American Ornithological Society Checklist of North and Middle American Birds. Available at https://academic.oup.com/auk/article/136/3/ukz042/5522257.

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Appendix C. Results of Species Richness Analyses: Run 1 (All Species) and Run 2 (Breeding Species Only).

Results, in figure format, are presented in this appendix for Run 1 (all species; Figures C-1 to C-13) first, followed by Run 2 (breeding species only; Figures C-14 to C-26). Results presented in the main report are for Run 3 (breeding species well-surveyed by point counts). Details on analytical methods are provided in Section 2.5.1 of the main report.

C.1 Run 1 (All Species)

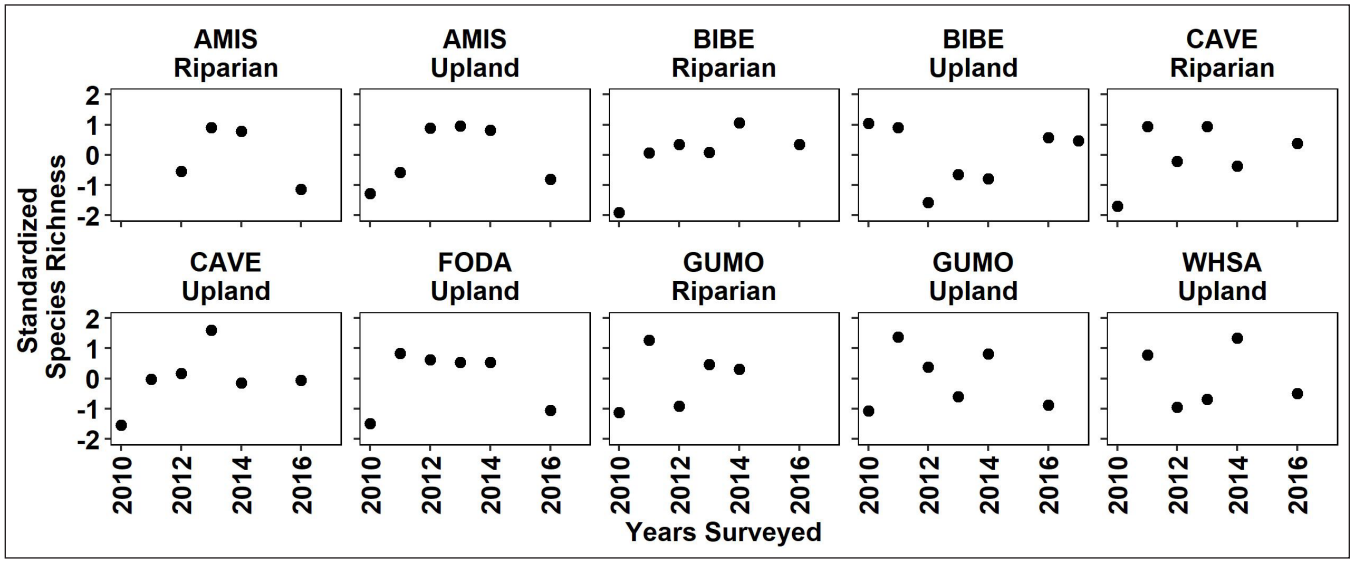


Figure C-1. Species richness first-order jackknife estimates for run 1 (all species), standardized using the across-years mean and standard deviation, in each surveyed Chihuahuan Desert Network park and habitat type. AMIS = Amistad NRA, BIBE = Big Bend NP, CAVE = Carlsbad Caverns NP, FODA = Fort Davis NHS, GUMO = Guadalupe Mountains NP, WHSA = White Sands NP.

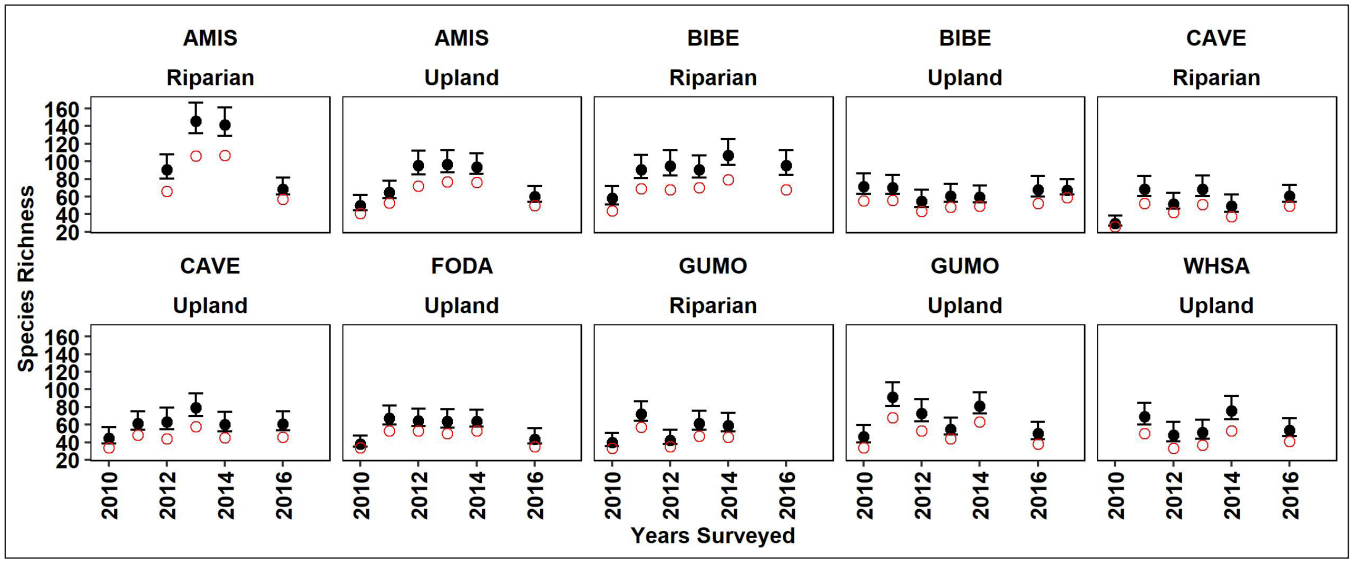


Figure C-2. Species richness raw (open, red circle) and first-order jackknife (black with 95% CL) estimates for each surveyed Chihuahuan Desert Network park and habitat type, by year surveyed. Analysis was for all species (run 1). AMIS = Amistad NRA, BIBE = Big Bend NP, CAVE = Carlsbad Caverns NP, FODA = Fort Davis NHS, GUMO = Guadalupe Mountains NP, WHSA = White Sands NP.

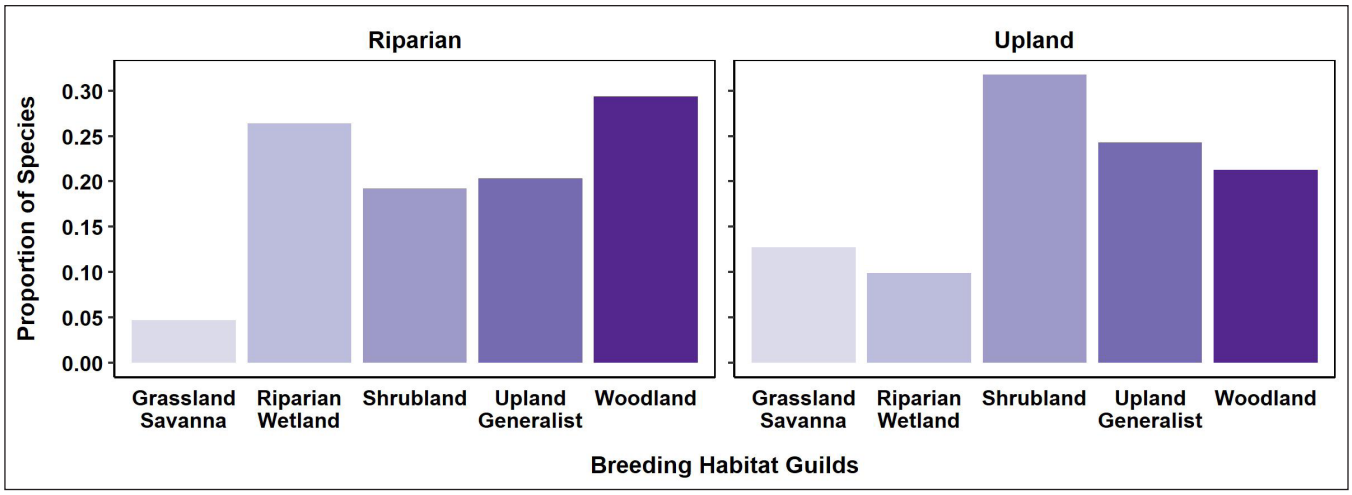


Figure C-3. The proportion of species in each breeding habitat guild for surveyed riparian and upland habitats averaged across parks and years in the Chihuahuan Desert Network. Analysis was for all species (run 1).

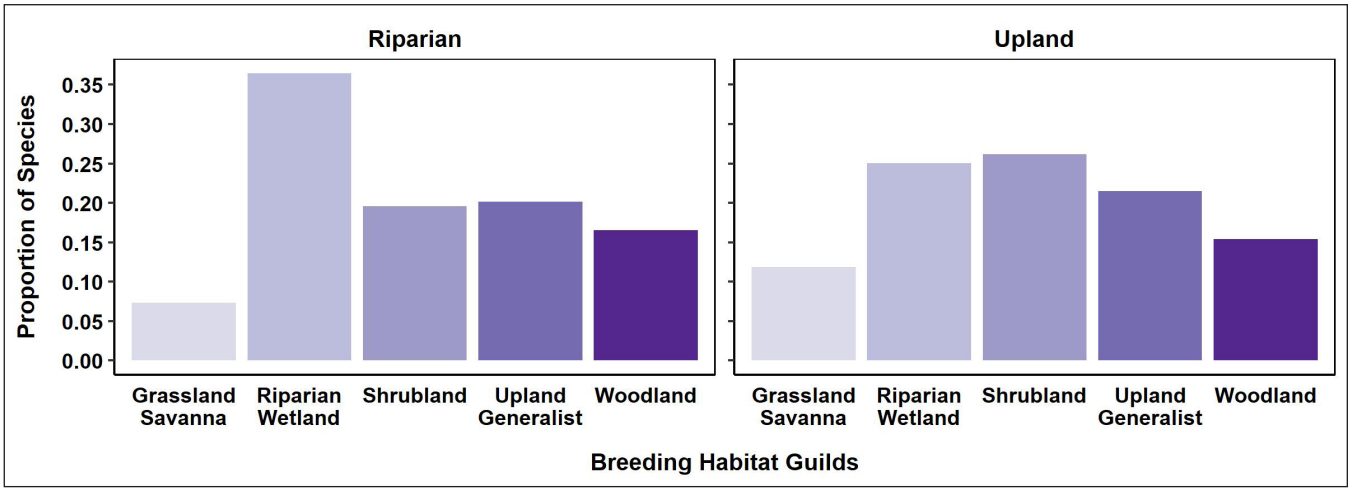


Figure C-4. The proportion of species in each breeding habitat guild for surveyed riparian and upland habitats in Amistad National Recreation Area, averaged over years. Analysis was for all species (run 1).

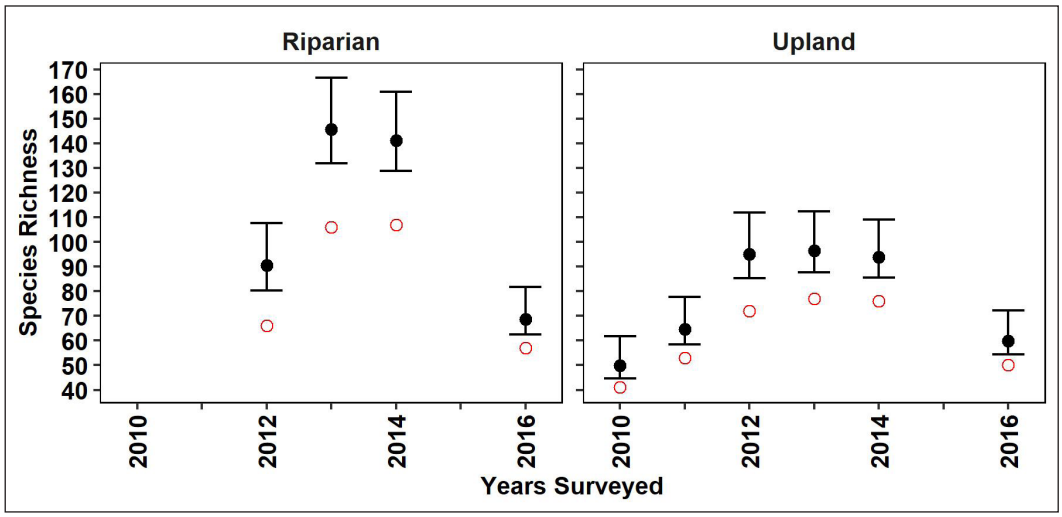


Figure C-5. Amistad National Recreation Area species richness raw (open, red circle) and first-order jackknife (black with 95% CL) estimates for each surveyed habitat type, by year surveyed. Analysis was for all species (run 1).

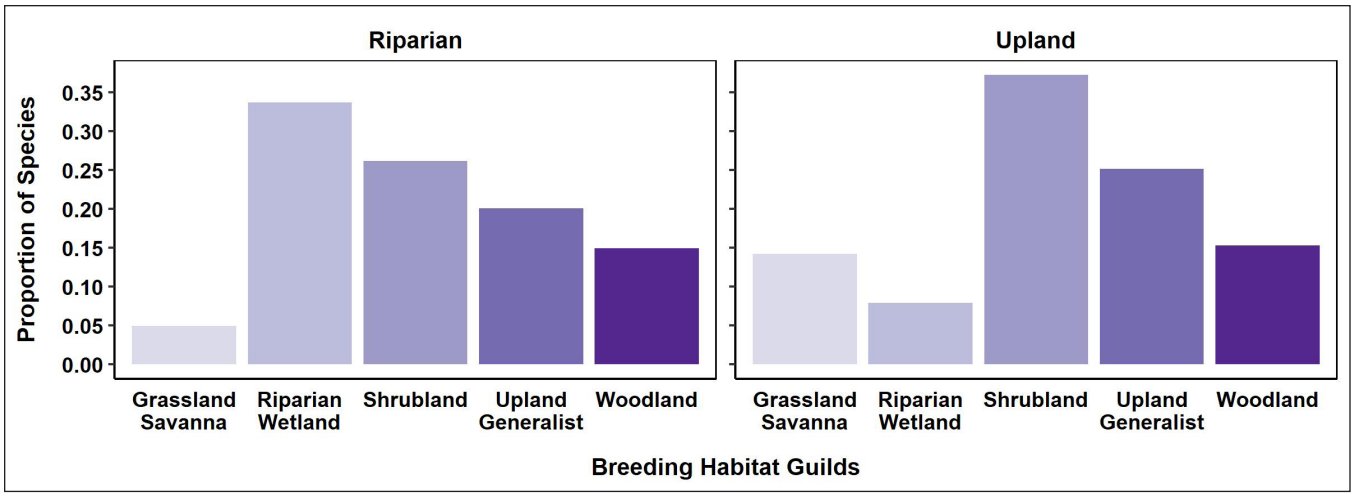


Figure C-6. The proportion of species in each breeding habitat guild for surveyed riparian and upland habitats in Big Bend National Park, averaged over years. Analysis was for all species (run 1).

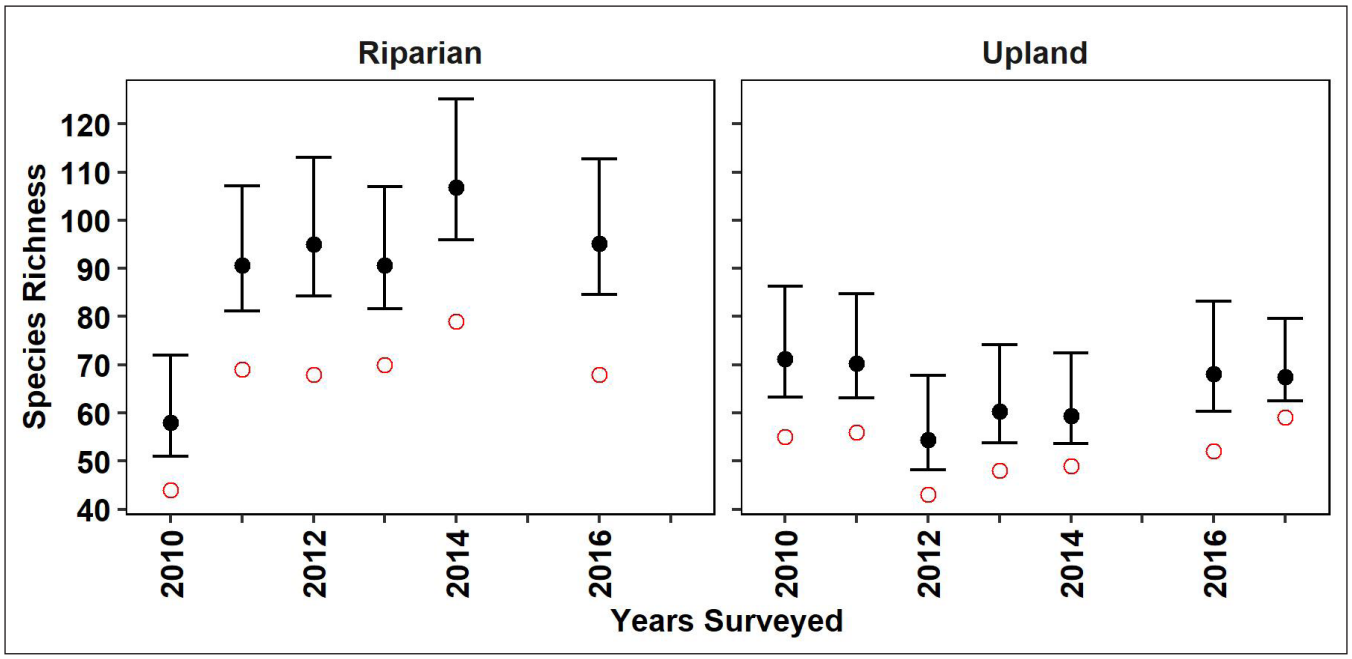


Figure C-7. Big Bend National Park species richness raw (open, red circle) and first-order jackknife (black with 95% CL) estimates for each surveyed habitat type, by year surveyed. Analysis was for all species (run 1).

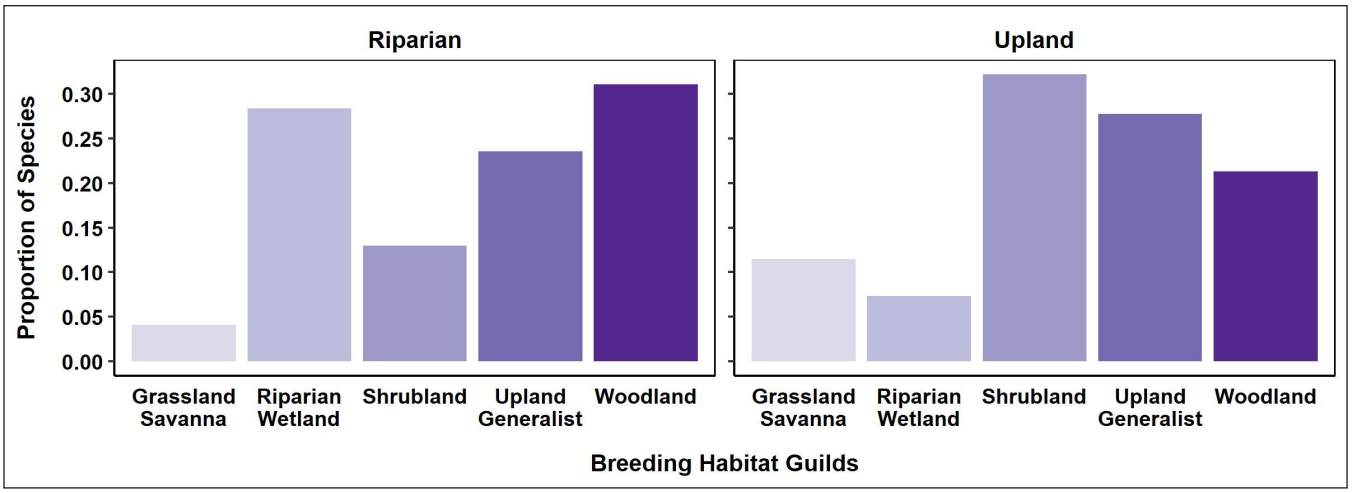


Figure C-8. The proportion of species in each breeding habitat guild for surveyed riparian and upland habitats in Carlsbad Caverns National Park, averaged over years. Analysis was for all species (run 1).

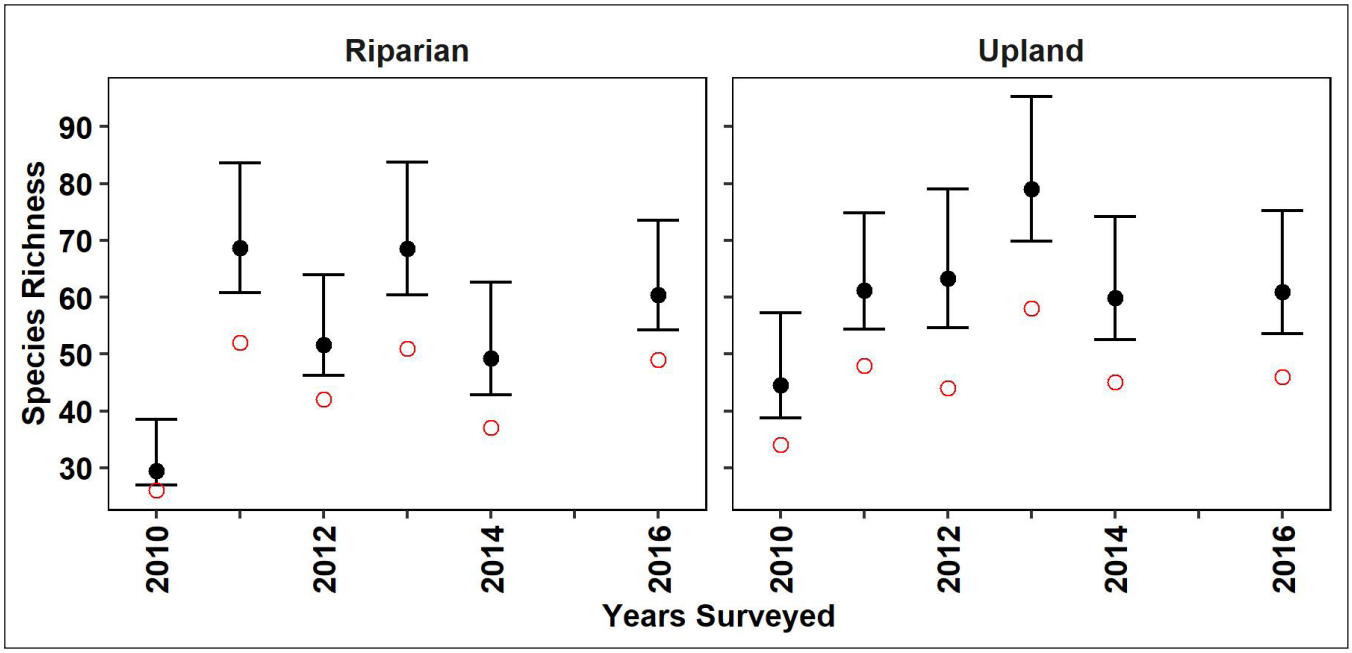


Figure C-9. Carlsbad Caverns National Park species richness raw (open, red circle) and first-order jackknife (black with 95% CL) estimates for each surveyed habitat type, by year surveyed. Analysis was for all species (run 1).

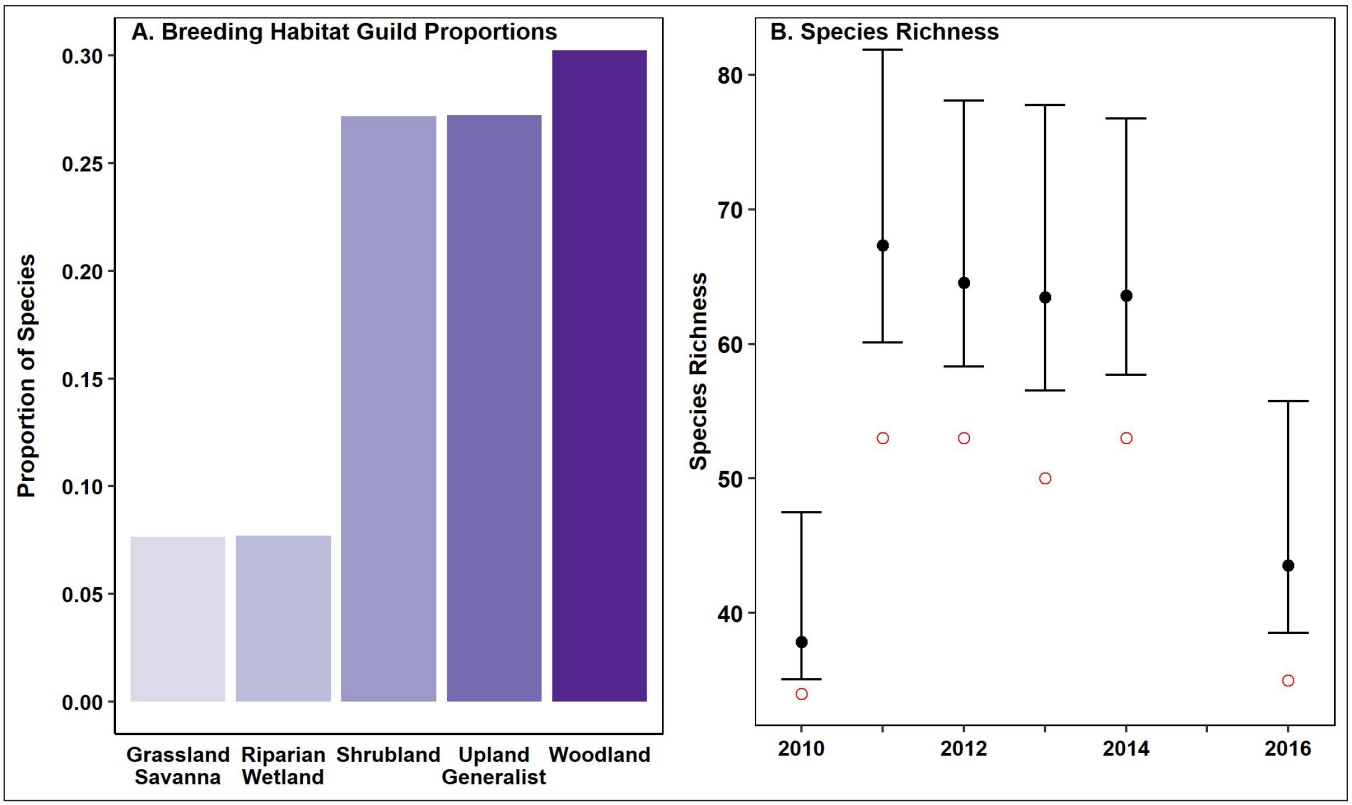


Figure C-10. The proportion of species in each breeding habitat guild for surveyed upland habitat in Fort Davis National Historic Site, averaged over years (a); and Fort Davis NHS species richness raw (open, red circle) and first-order jackknife (black with 95% CL) estimates in upland habitat for years surveyed (b). Analysis used all species (run 1).

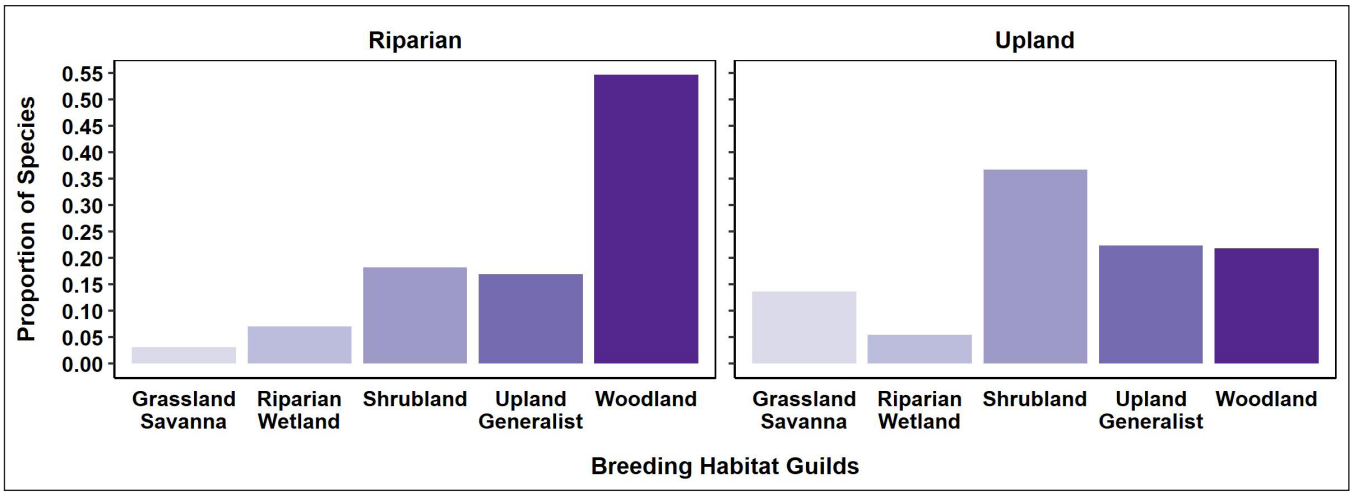


Figure C-11. The proportion of species in each breeding habitat guild for surveyed riparian and upland habitats in Guadalupe Mountains National Park, averaged over years. Analysis was for all species (run 1).

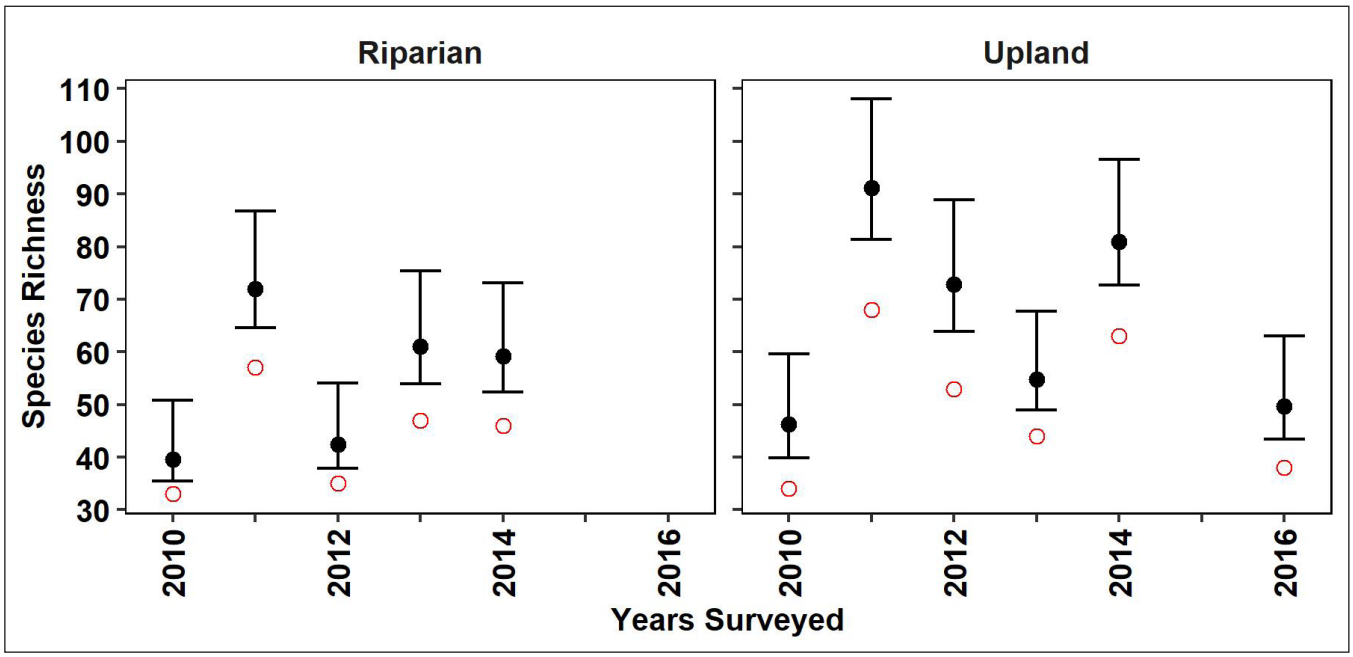


Figure C-12. Guadalupe Mountains National Park species richness raw (open, red circle) and first-order jackknife (black with 95% CL) estimates for each surveyed habitat type, by year surveyed. Analysis was for all species (run 1).

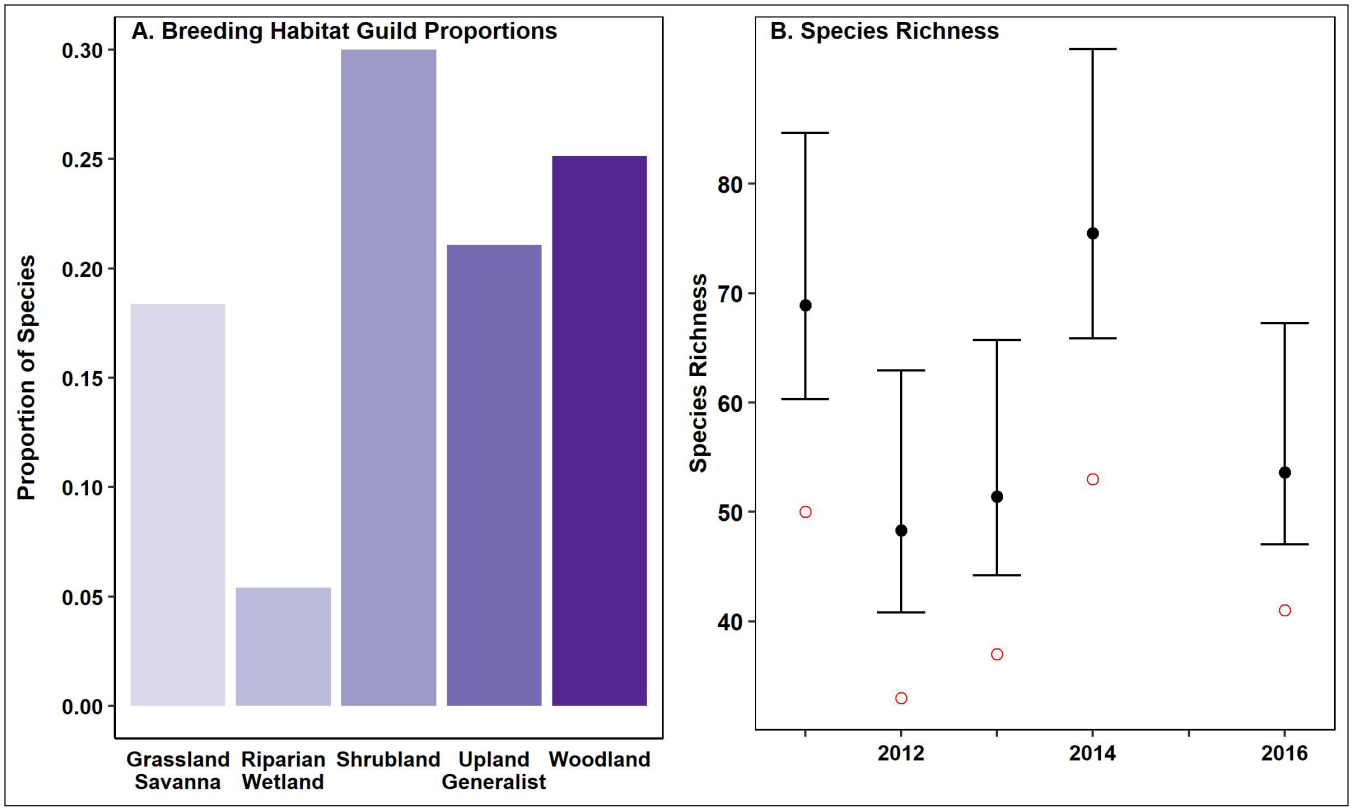


Figure C-13. The proportion of species in each breeding habitat guild for surveyed upland habitat in White Sands National Park, averaged over years (a); and White Sands National Park species richness raw (open, red circle) and first-order jackknife (black with 95% CL) estimates in upland habitat for years surveyed (b). Analysis used all species (run 1).

C.2 Run 2 (Breeding Species Only)

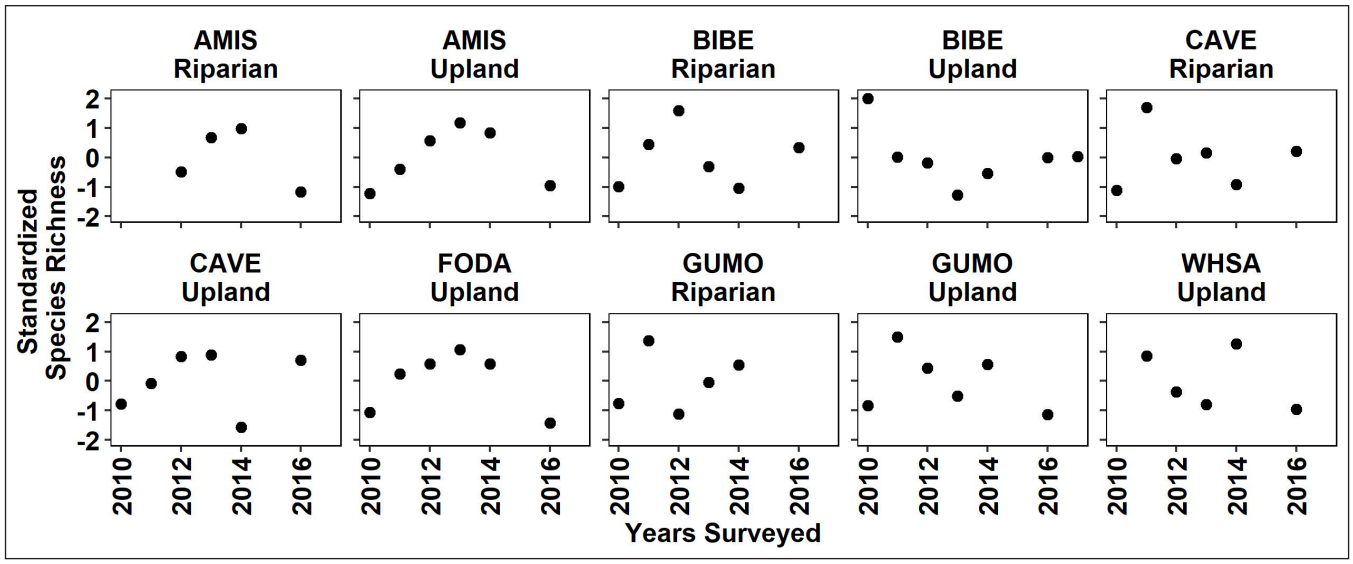


Figure C-14. Species richness first-order jackknife estimates for run 2 (breeding species only), standardized using the across-years mean and standard deviation, in each surveyed Chihuahuan Desert Network park and habitat type. AMIS = Amistad NRA, BIBE = Big Bend NP, CAVE = Carlsbad Caverns NP, FODA = Fort Davis NHS, GUMO = Guadalupe Mountains NP, WHSA = White Sands NP.

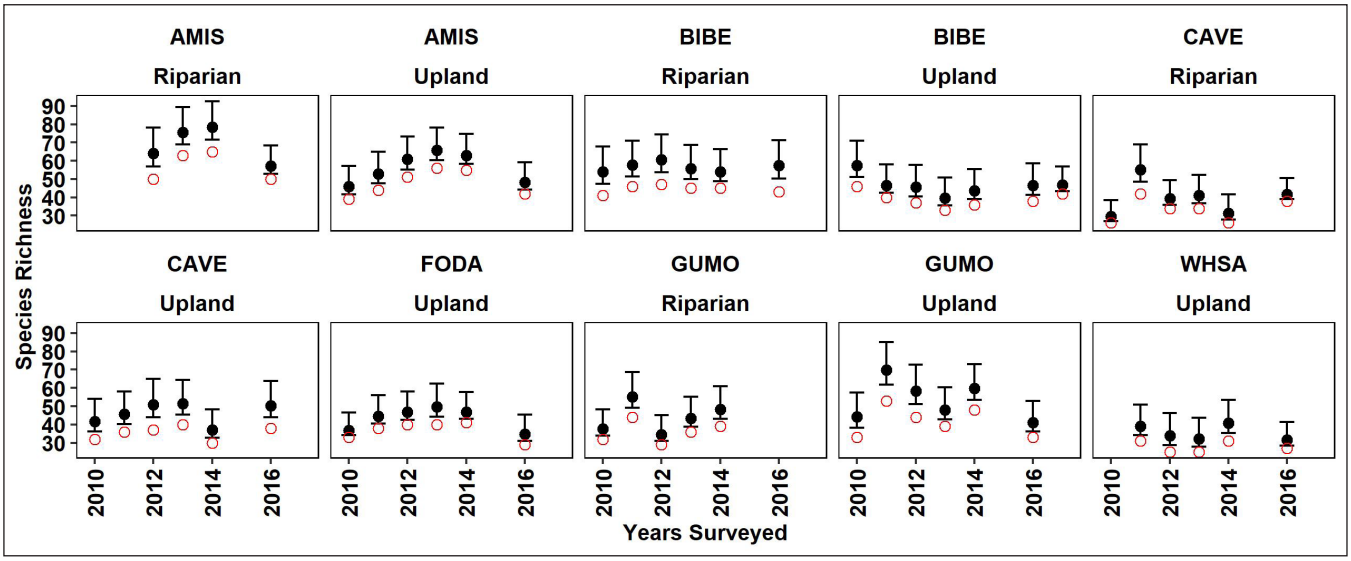


Figure C-15. Species richness raw (open, red circle) and first-order jackknife (black with 95% CL) estimates for each surveyed Chihuhuan Desert Network park and habitat type, by year surveyed. Analysis was for breeding species only (run 2). AMIS = Amistad NRA, BIBE = Big Bend NP, CAVE = Carlsbad Caverns NP, FODA = Fort Davis NHS, GUMO = Guadalupe Mountains NP, WHSA = White Sands NP.

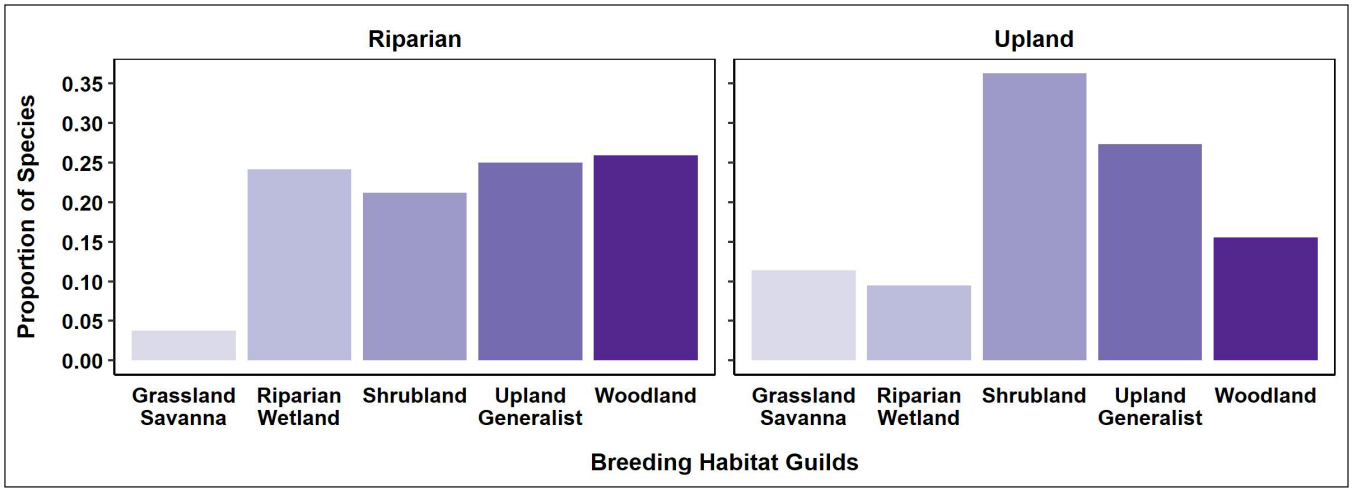


Figure C-16. The proportion of species in each breeding habitat guild for surveyed riparian and upland habitats averaged across parks and years in the Chihuahuan Desert Network. Analysis was for breeding species only (run 2).

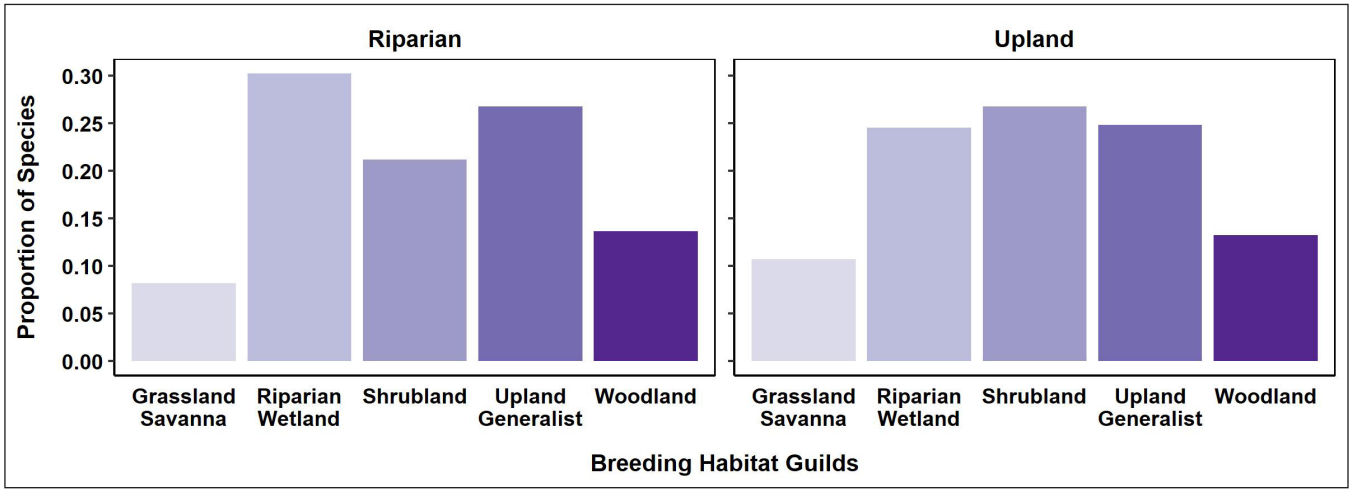


Figure C-17. The proportion of species in each breeding habitat guild for surveyed riparian and upland habitats in Amistad National Recreation Area, averaged over years. Analysis was for breeding species only (run 2).

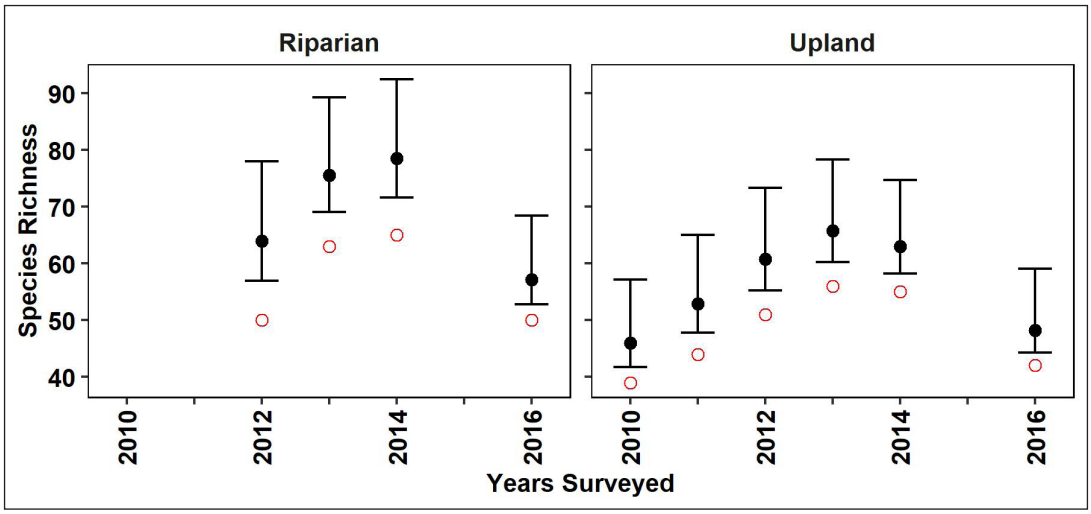


Figure C-18. Amistad National Recreation Area species richness raw (open, red circle) and first-order jackknife (black with 95% CL) estimates for each surveyed habitat type, by year surveyed. Analysis was for breeding species only (run 2).

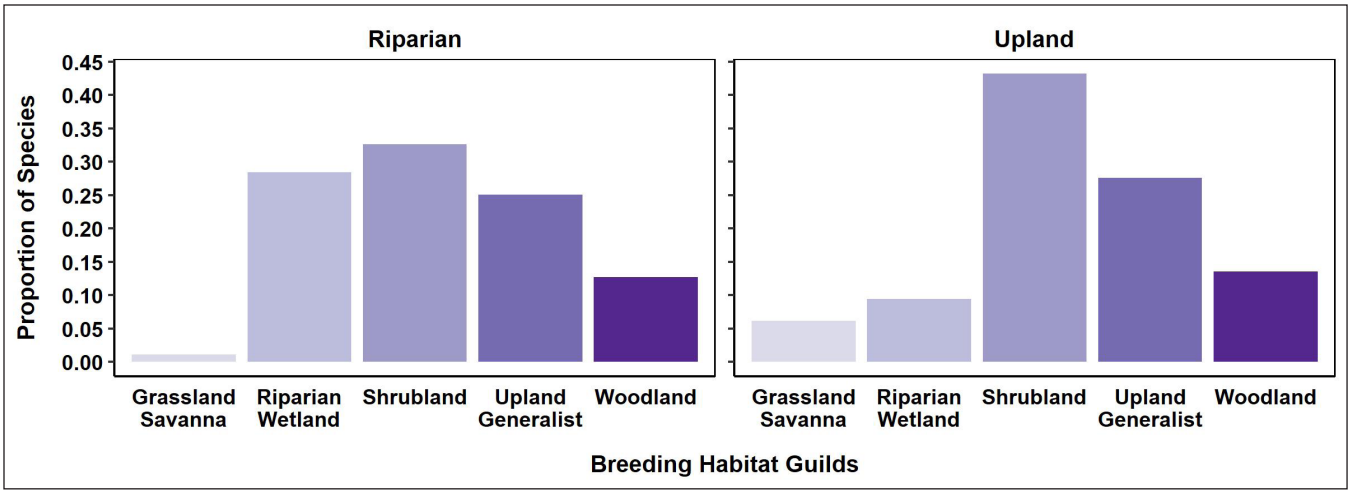


Figure C-19. The proportion of species in each breeding habitat guild for surveyed riparian and upland habitats in Big Bend National Park, averaged over years. Analysis was for breeding species only (run 2).

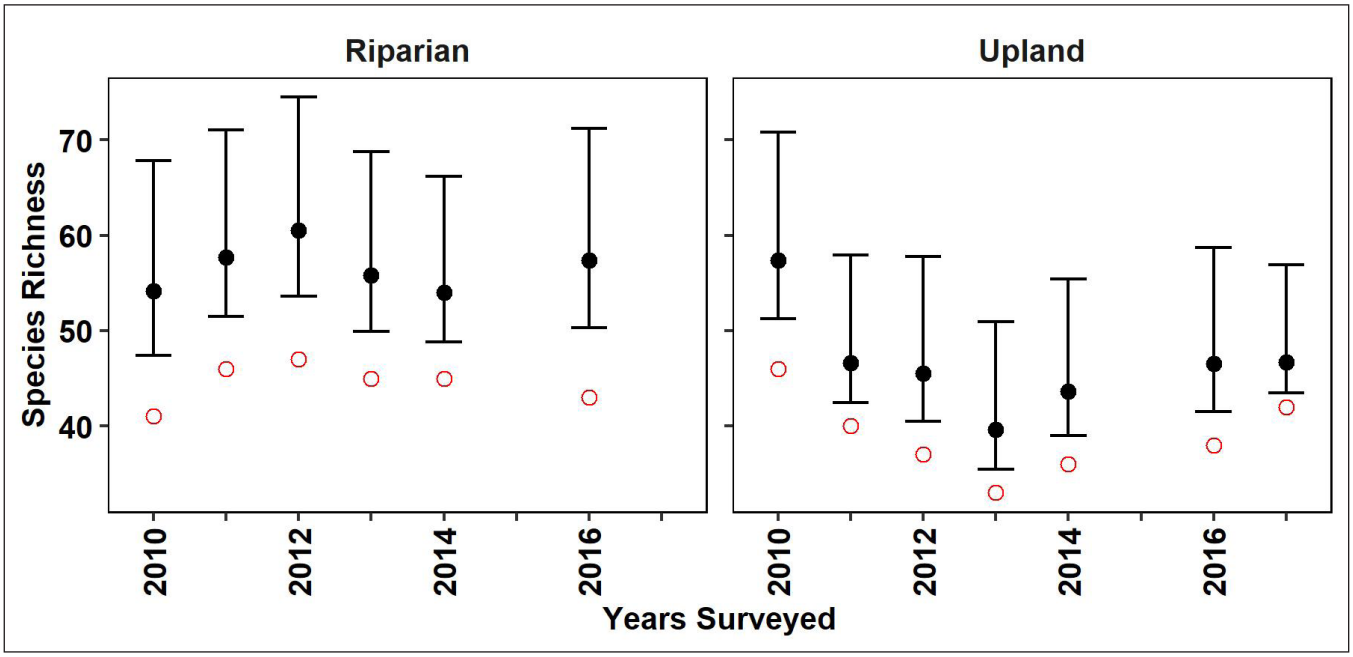


Figure C-20. Big Bend National Park species richness raw (open, red circle) and first-order jackknife (black with 95% CL) estimates for each surveyed habitat type, by year surveyed. Analysis was for breeding species only (run 2).

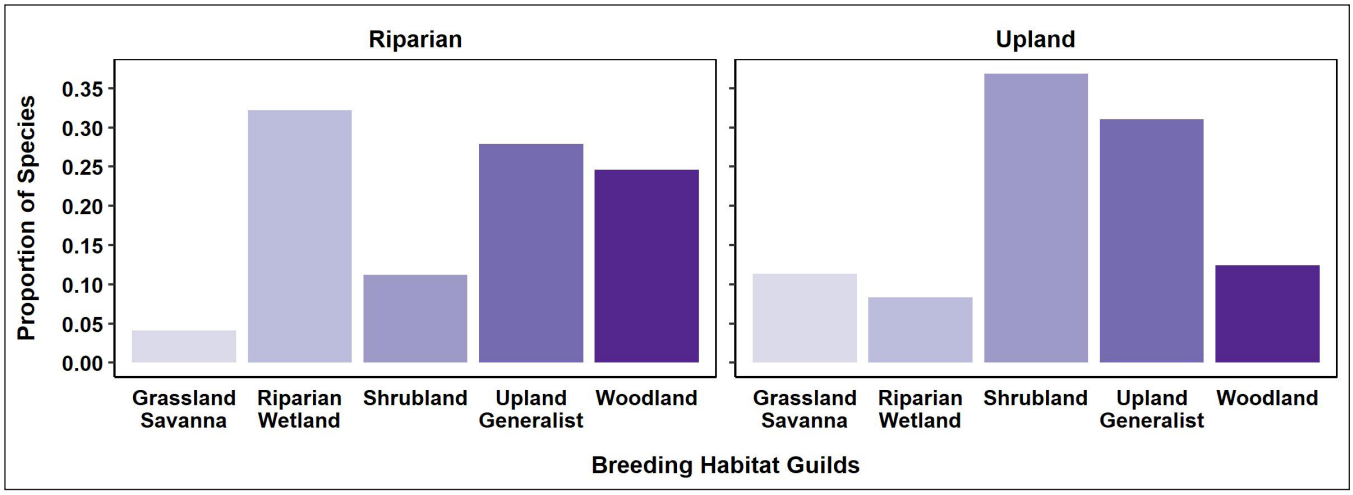


Figure C-21. The proportion of species in each breeding habitat guild for surveyed riparian and upland habitats in Carlsbad Caverns National Park, averaged over years. Analysis was for breeding species only (run 2).

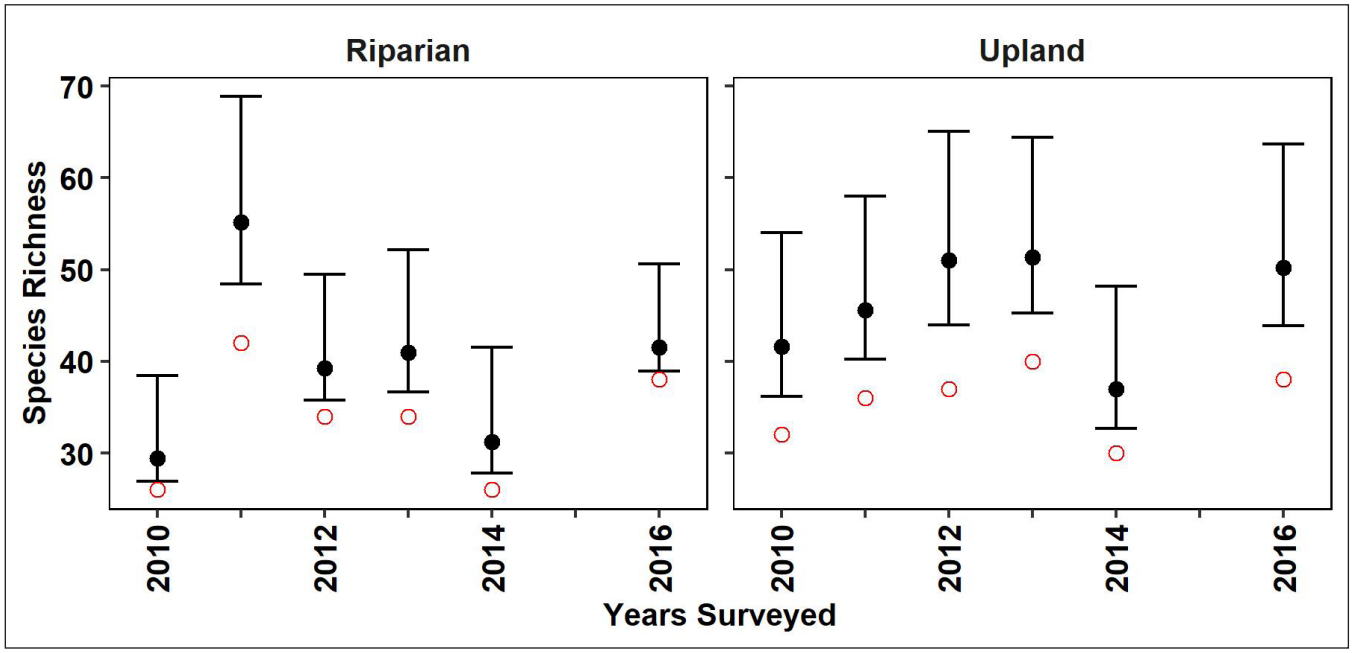


Figure C-22. Carlsbad Caverns National Park species richness raw (open, red circle) and first-order jackknife (black with 95% CL) estimates for each surveyed habitat type, by year surveyed. Analysis was for breeding species only (run 2).

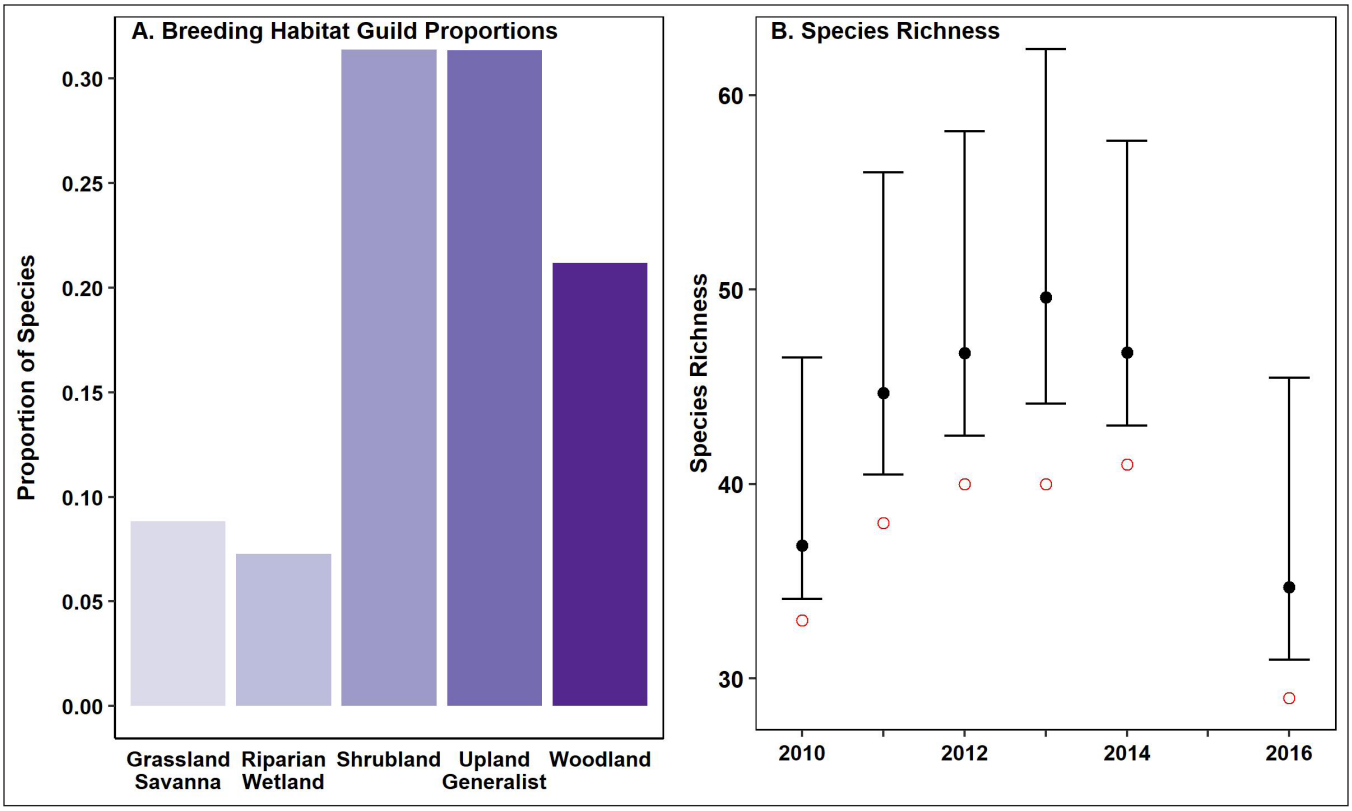


Figure C-23. The proportion of species in each breeding habitat guild for surveyed upland habitat in Fort Davis National Historic Site, averaged over years (a); and Fort Davis NHS species richness raw (open, red circle) and first-order jackknife (black with 95% CL) estimates in upland habitat for years surveyed (b). Analysis used breeding species only (run 2).

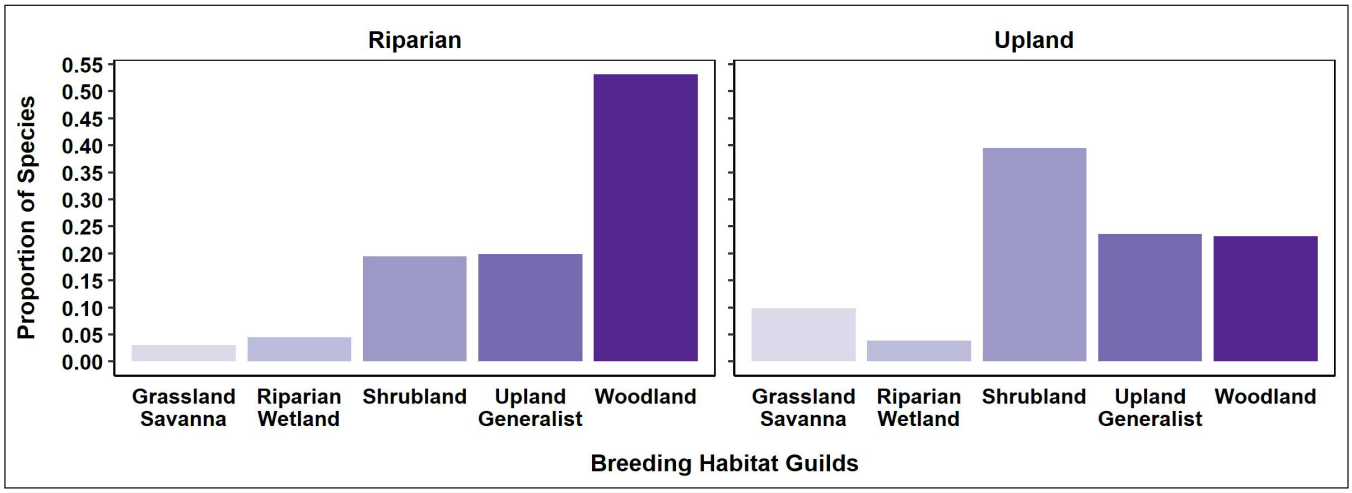


Figure C-24. The proportion of species in each breeding habitat guild for surveyed riparian and upland habitats in Guadalupe Mountains National Park, averaged over years. Analysis was for breeding species only (run 2).

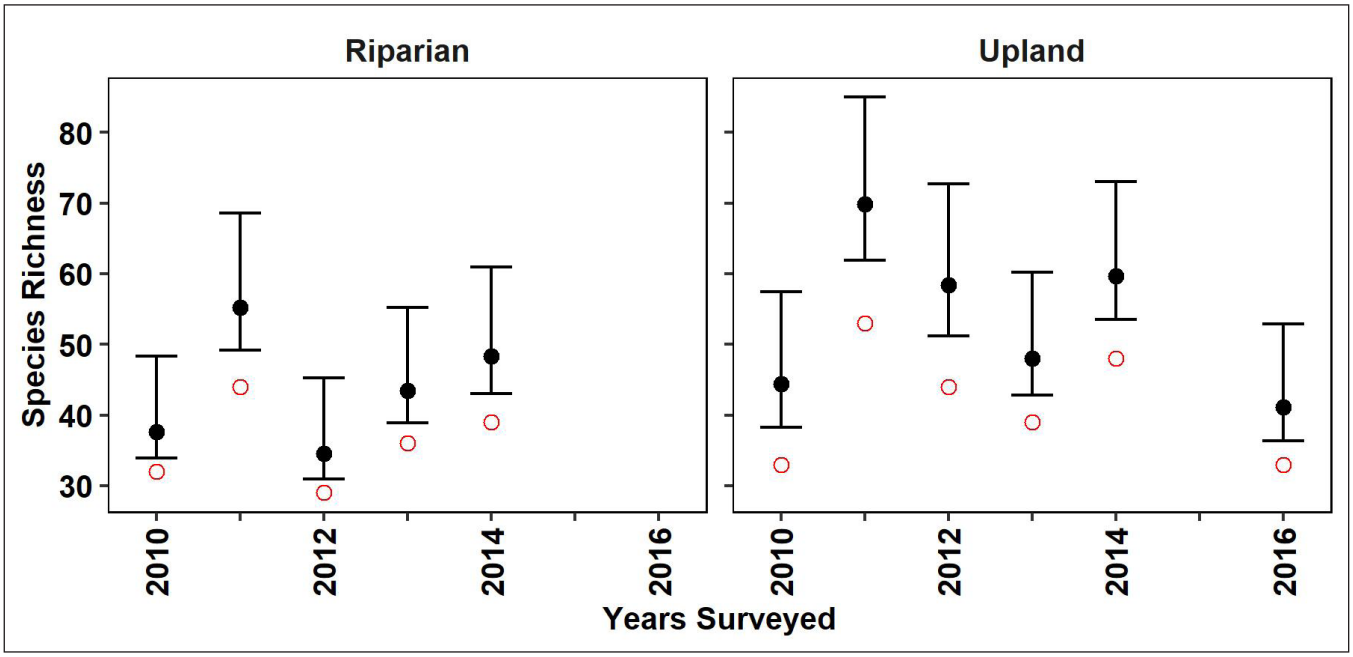


Figure C-25. Guadalupe Mountains National Park species richness raw (open, red circle) and first-order jackknife (black with 95% CL) estimates for each surveyed habitat type, by year surveyed. Analysis was for breeding species only (run 2).

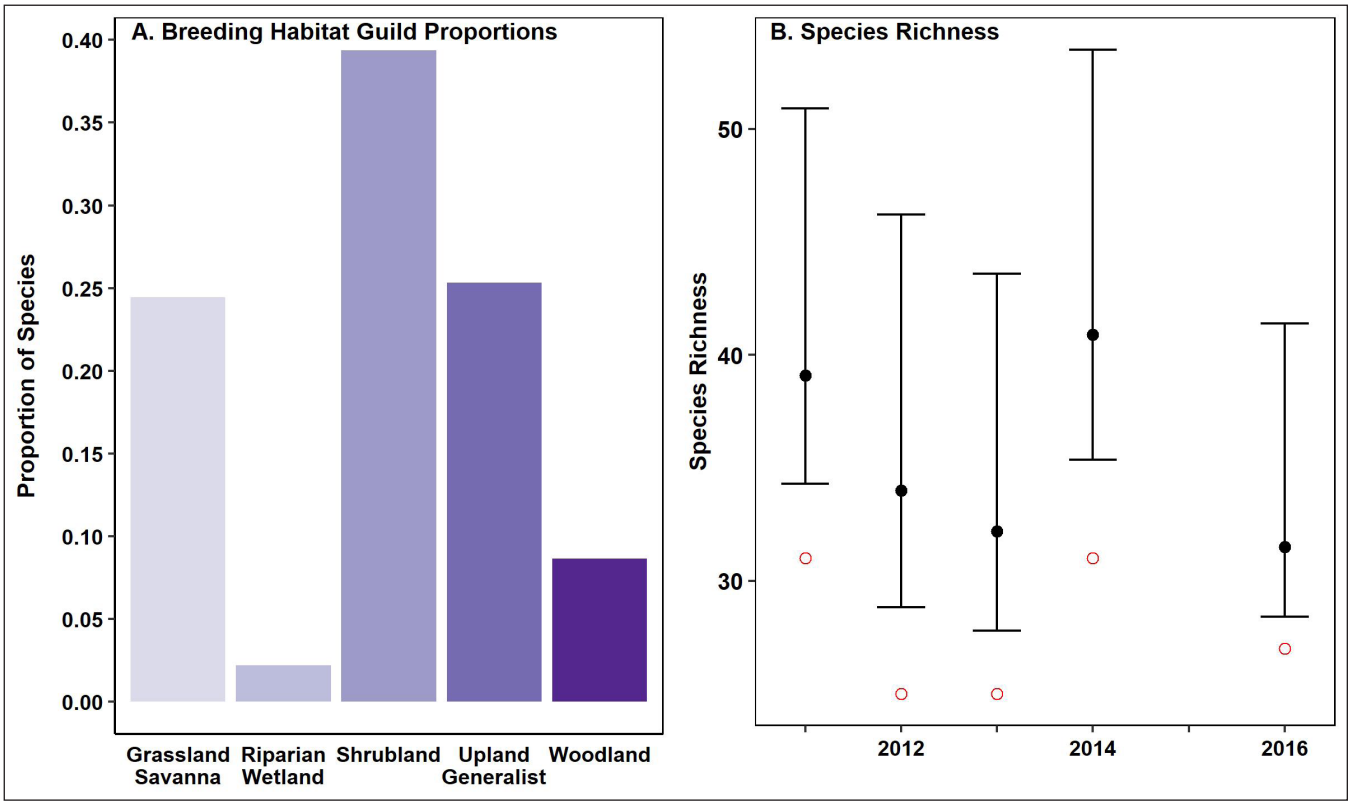


Figure C-26. The proportion of species in each breeding habitat guild for surveyed upland habitat in White Sands National Park, averaged over years (a); and White Sands National Park species richness raw (open, red circle) and first-order jackknife (black with 95% CL) estimates in upland habitat for years surveyed (b). Analysis used breeding species only (run 2).

Appendix D. Annual Probability of Occupancy for Landbird Species by Park-Habitat and Breeding Habitat Guild

This appendix shows annual probability of occupancy for landbird species according to park-habitat and breeding habitat guild (Figures D-1 to D-44). Occupancy estimates presented in the main report (in the species accounts) are by species and park-habitat, and the estimates were averaged over years. Note that three types of occupancy estimates are provided in this appendix: probability of occupancy for transects (black/solid), for points within occupied transects (conditional point occupancy; red/dashed), and for points (unconditional point occupancy; red/solid). Unconditional point occupancy estimates are provided for park-habitats with only one transect (i.e., Fort Davis National Historic Site Upland, Carlsbad Caverns National Park [NP] Riparian, and Guadalupe Mountains NP Riparian). Details on occupancy analytical methods are provided in Section 2.5.2 of the main report.

With the Bayesian dynamic occupancy approach used, we could produce occupancy estimates for years with no data collection. We provide estimates for uplands for 2010–2017, as the last year of any upland sampling was 2017 in Big Bend NP. Within this span, there was no upland data collection (but estimates are provided) for White Sands NP in 2010, for any park in 2015, or for any park other than Big Bend NP in 2017. For each park with riparian transects, we provide estimates for 2010–2016, as 2016 was the last year of riparian sampling in all parks. Within this span, there was no riparian data collection (but estimates are still provided) for Amistad National Recreation Area in 2010 and 2011, or for any park in 2015. Also note that some species are included here that are not included in the Chapter 3 species accounts (they did not meet our criteria for inclusion in Chapter 3). Conversely, note that some species can have poor precision in yearly estimates but acceptable precision in across-year average occupancy estimates reported in Chapter 3.

Table D-1 at the end of this appendix contains the four-letter species codes, used in the figures, and the corresponding common names.

D.1 Amistad National Recreation Area (NRA) Upland Habitat

Grassland breeding habitat guild

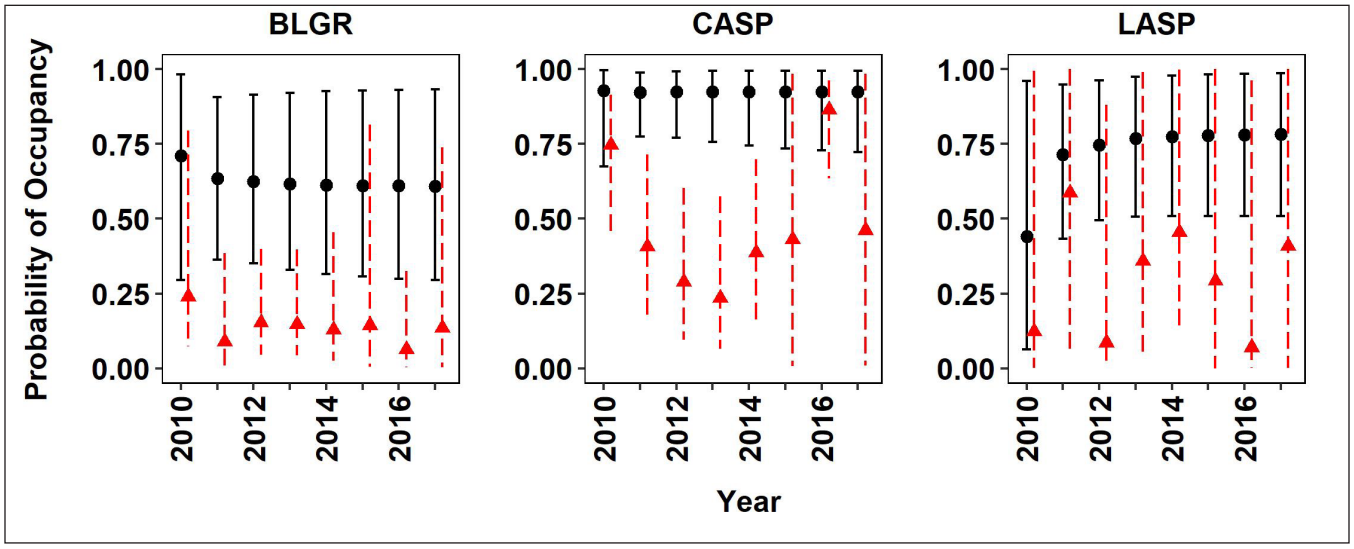


Figure D-1. Estimated probability of occupancy, for members of the grassland breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from Amistad NRA upland surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. Species codes available in appendix table.

Upland generalist breeding habitat guild

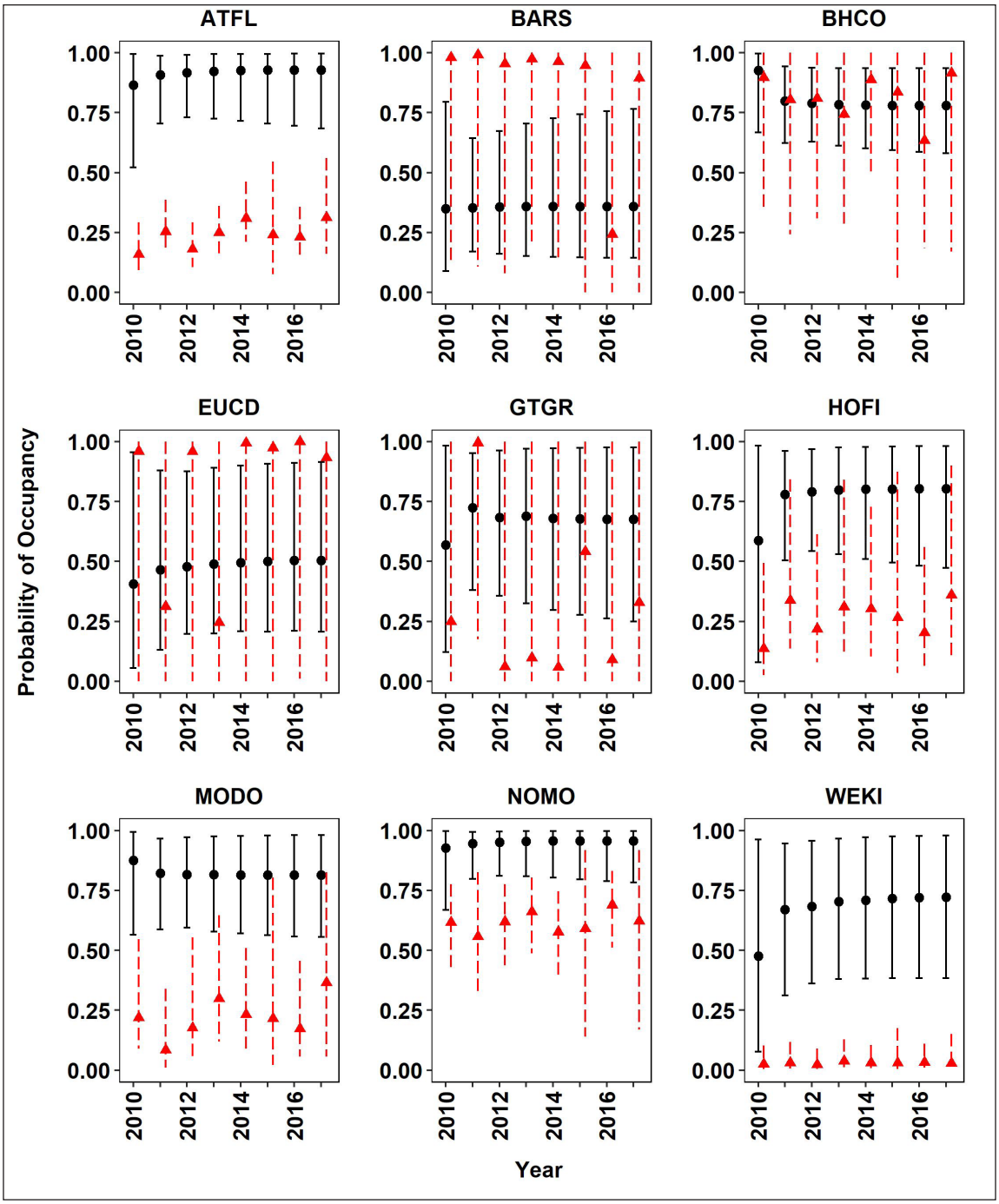


Figure D-2. Estimated probability of occupancy, for members of the upland generalist breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from Amistad NRA upland surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. Species codes available in appendix table.

Shrubland breeding habitat guild

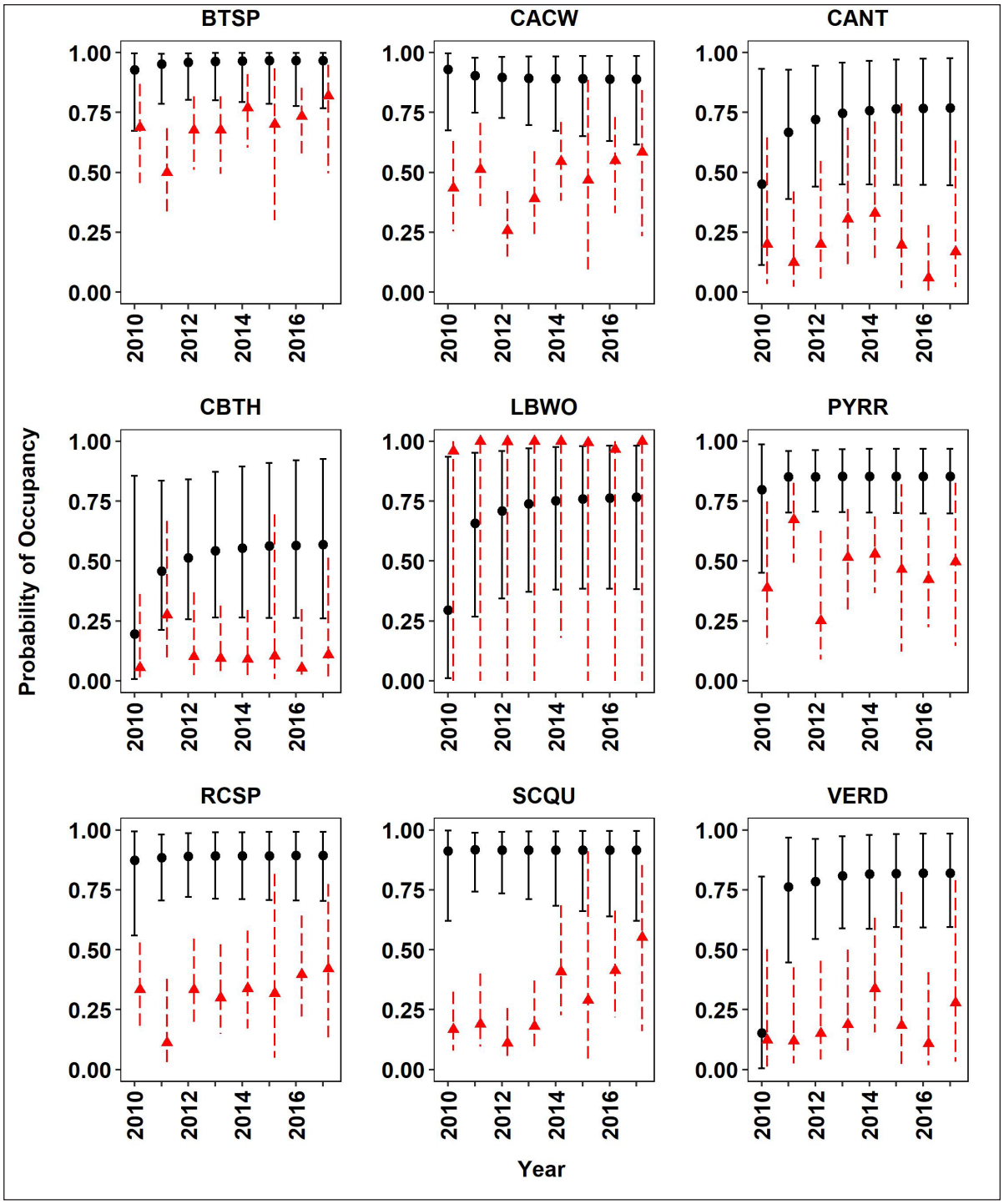


Figure D-3. Estimated probability of occupancy, for members of the shrubland breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from Amistad NRA upland surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. Species codes available in appendix table.

Woodland breeding habitat guild

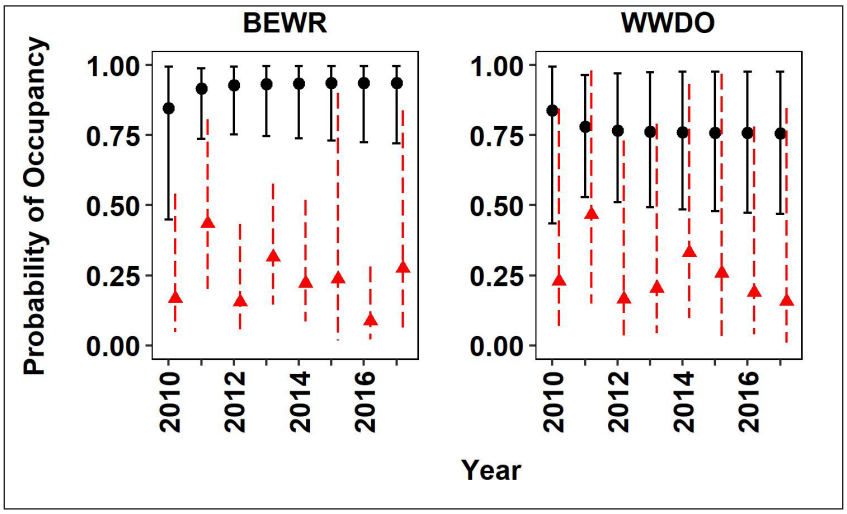


Figure D-4. Estimated probability of occupancy, for members of the woodland breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from Amistad NRA upland surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. BEWR = Bewick's Wren, WWDO = White-winged Dove.

Riparian/wetland breeding habitat guild

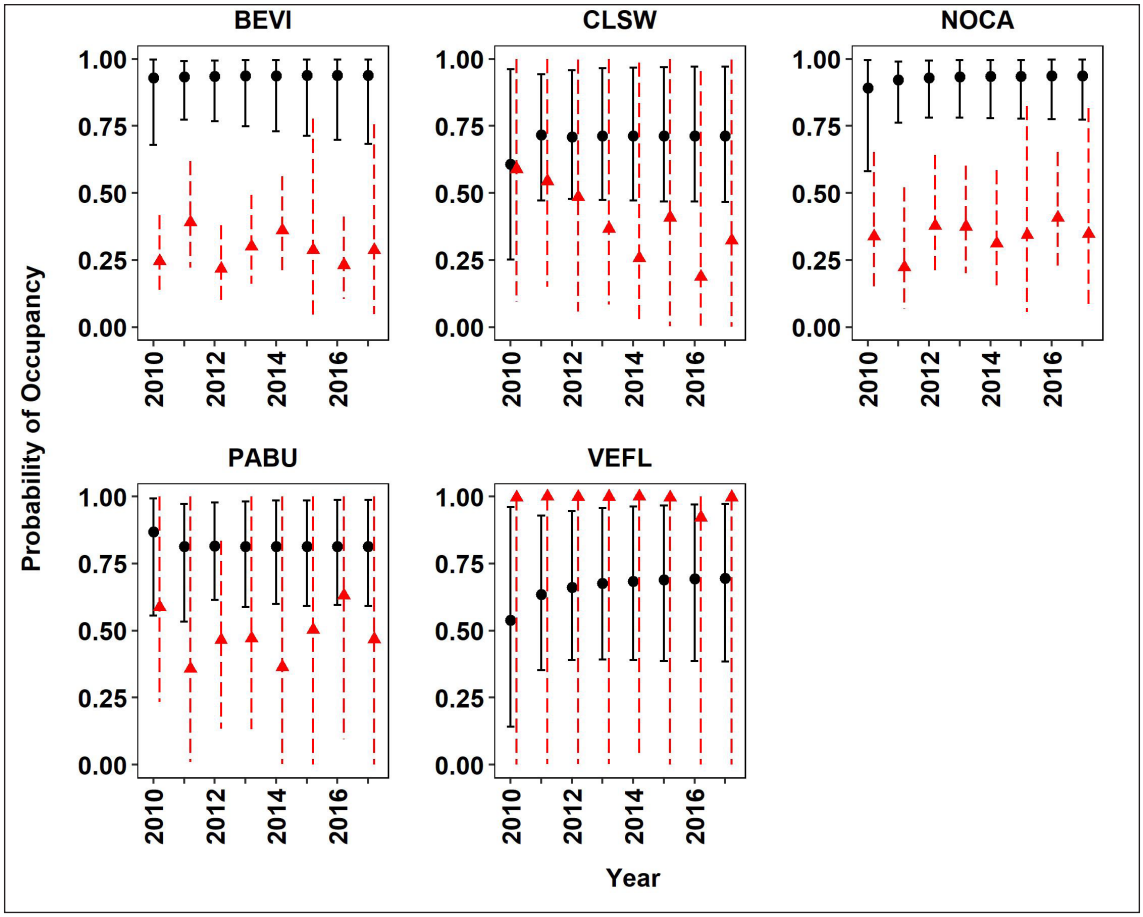


Figure D-5. Estimated probability of occupancy, for members of the riparian/wetland breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from Amistad NRA upland surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. Species codes available in appendix table.

D.2 Amistad NRA Riparian Habitat

Upland generalist breeding habitat guild

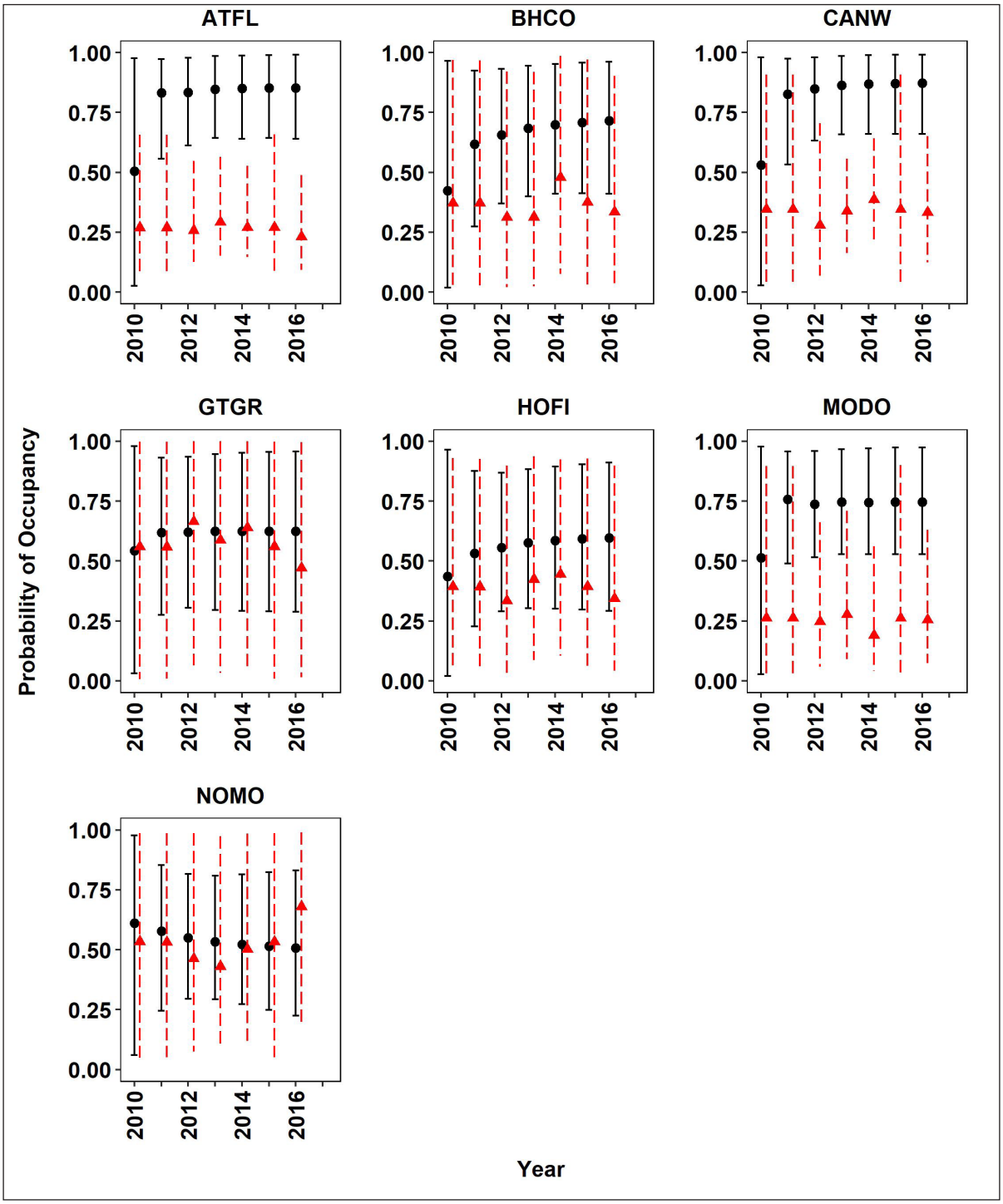


Figure D-6. Estimated probability of occupancy, for members of the upland generalist breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from Amistad NRA riparian surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. Species codes available in appendix table.

Grassland breeding habitat guild

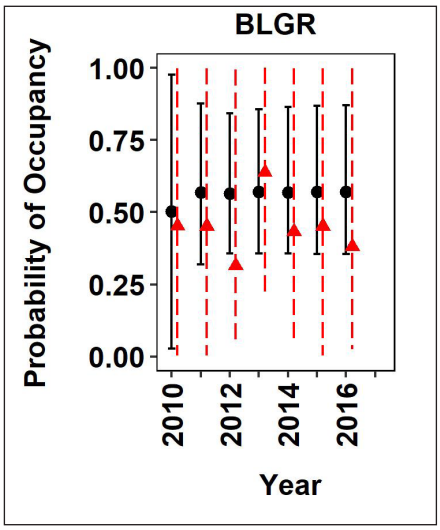


Figure D-7. Estimated probability of occupancy, for a member of the grassland breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from Amistad NRA riparian surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. BLGR = Blue Grosbeak.

Shrubland breeding habitat guild

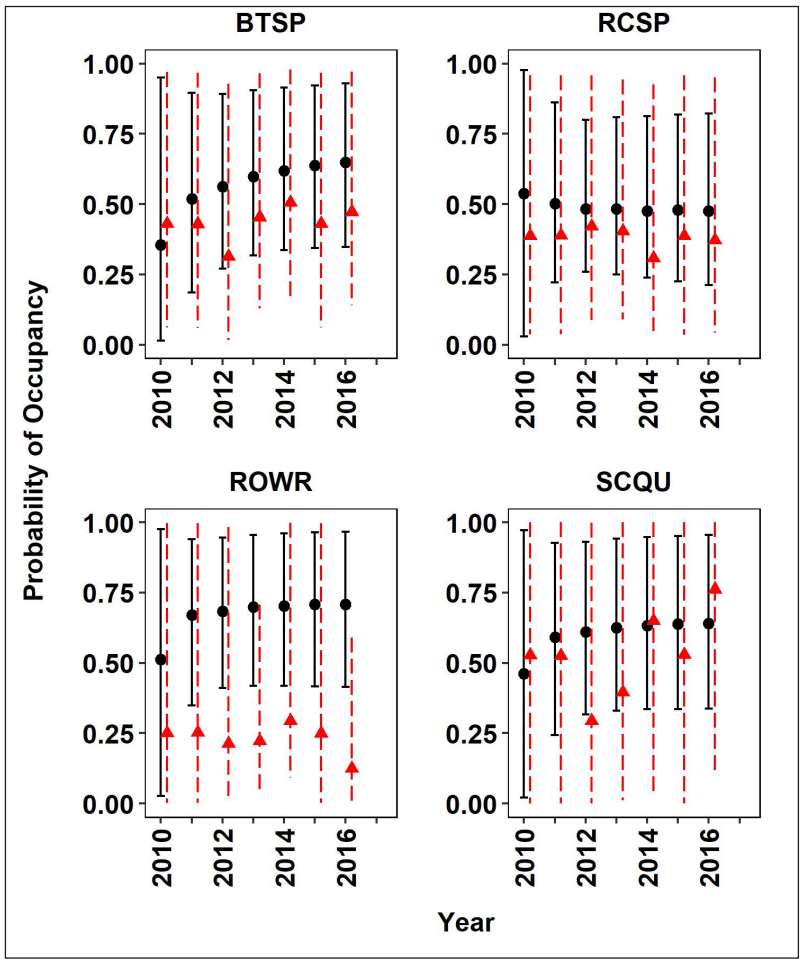


Figure D-8. Estimated probability of occupancy, for members of the shrubland breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from Amistad NRA riparian surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. Species codes available in appendix table.

Woodland breeding habitat guild

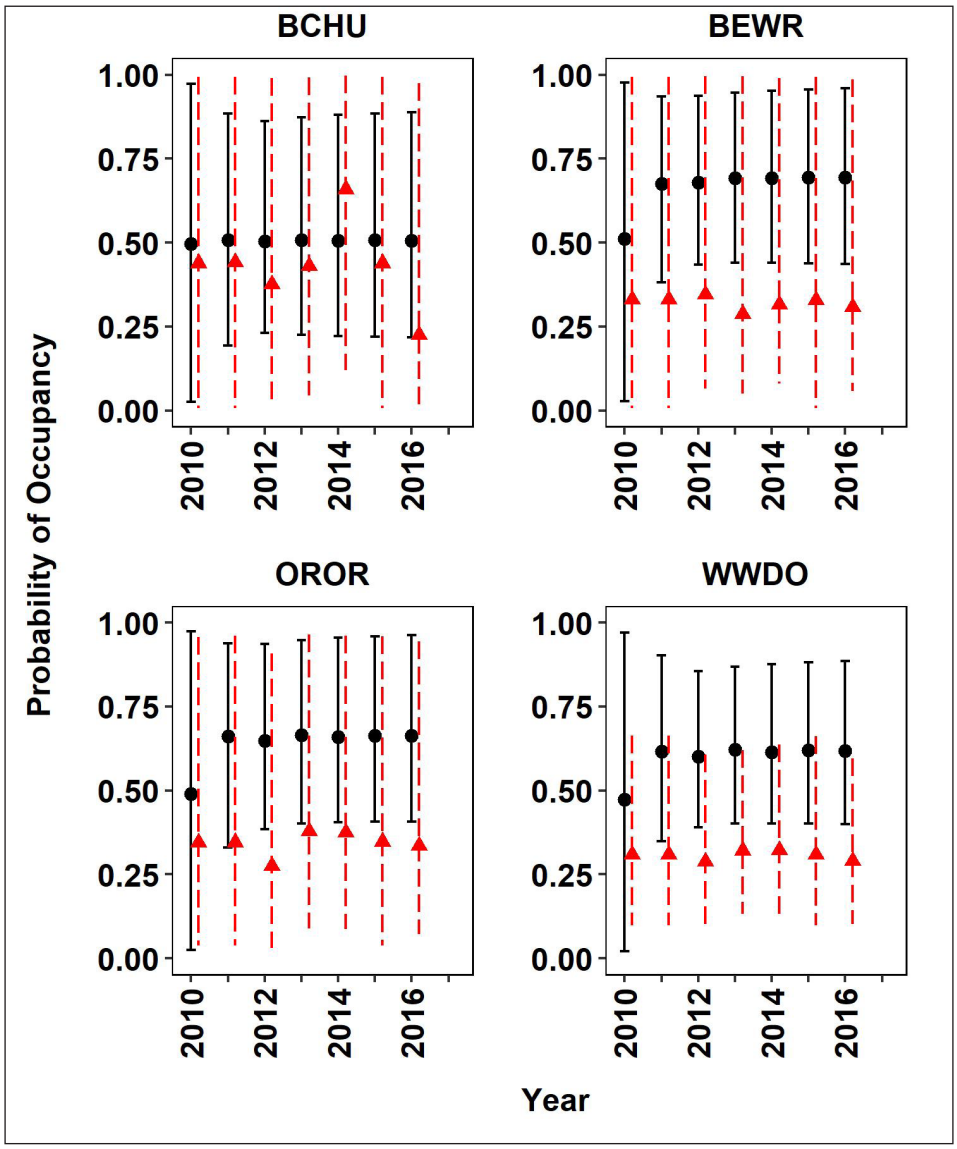


Figure D-9. Estimated probability of occupancy, for members of the woodland breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from Amistad NRA riparian surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. Species codes available in appendix table.

Riparian/wetland breeding habitat guild

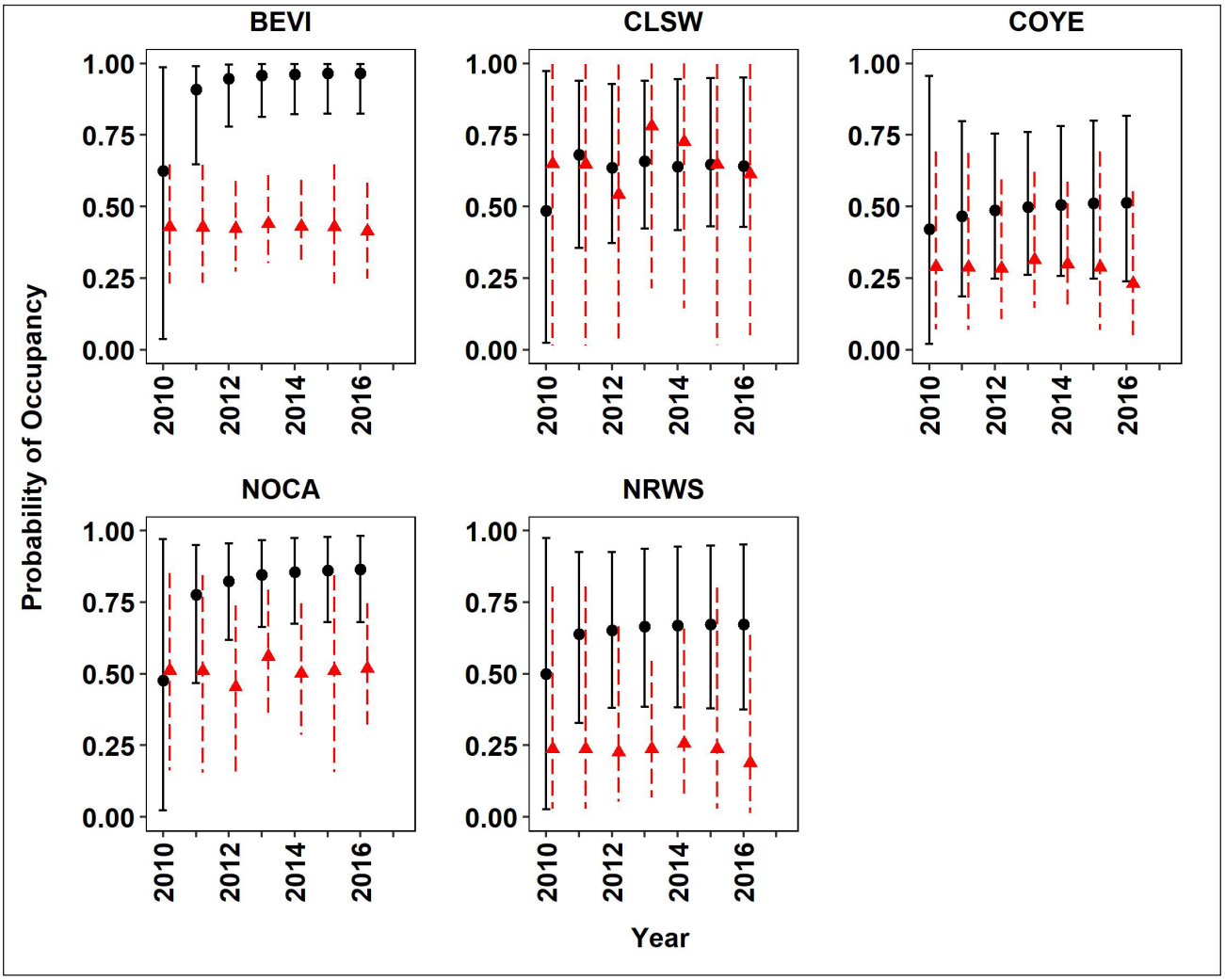


Figure D-10a. Estimated probability of occupancy, for members of the riparian/wetland breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from Amistad NRA riparian surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. Species codes available in appendix table.

Riparian/wetland breeding habitat guild...continued

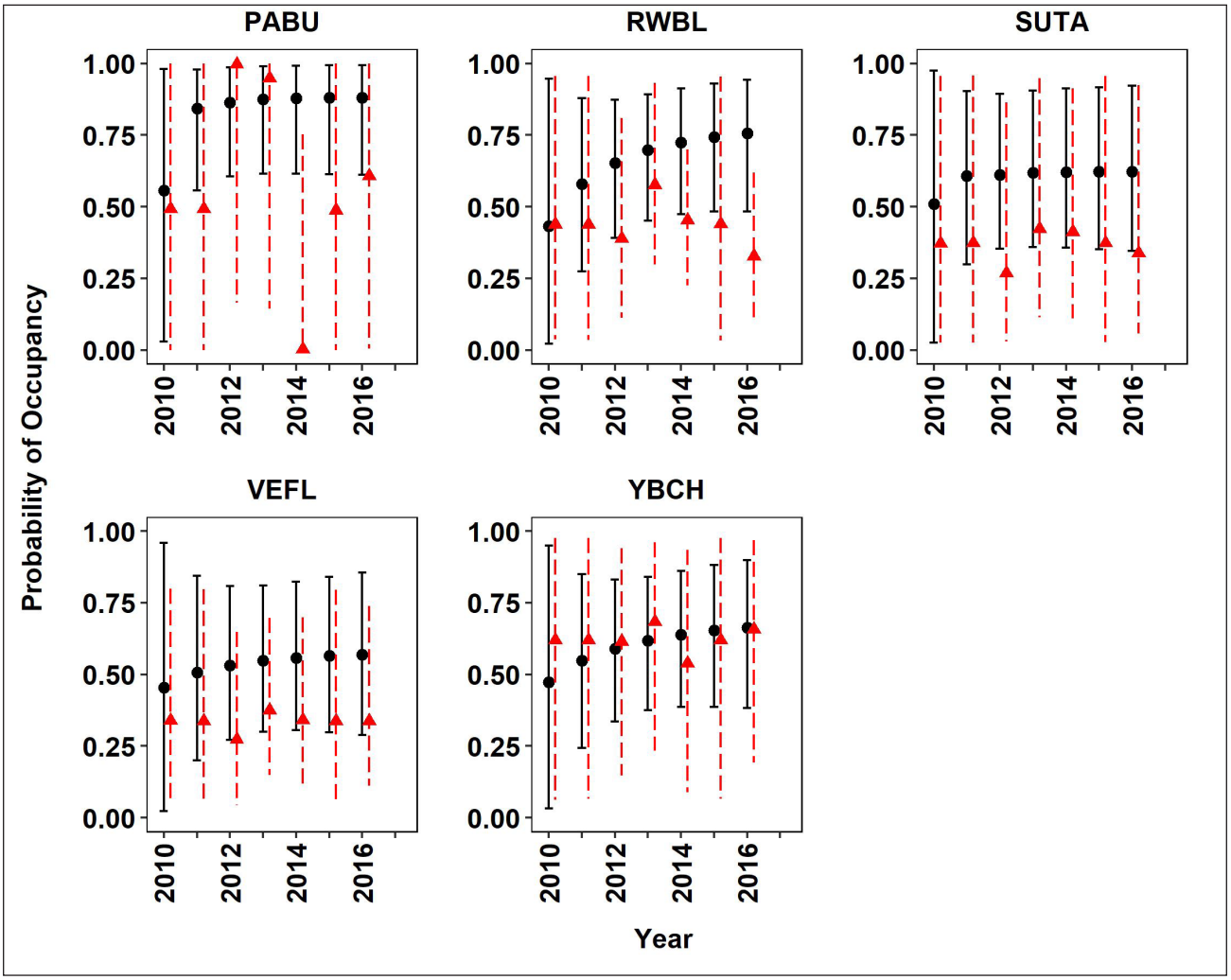


Figure D-10b. Estimated probability of occupancy, for more members of the riparian/wetland breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from Amistad NRA riparian surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. Species codes available in appendix table.

D.3 Big Bend National Park (NP) Upland Habitat

Upland generalist breeding habitat guild

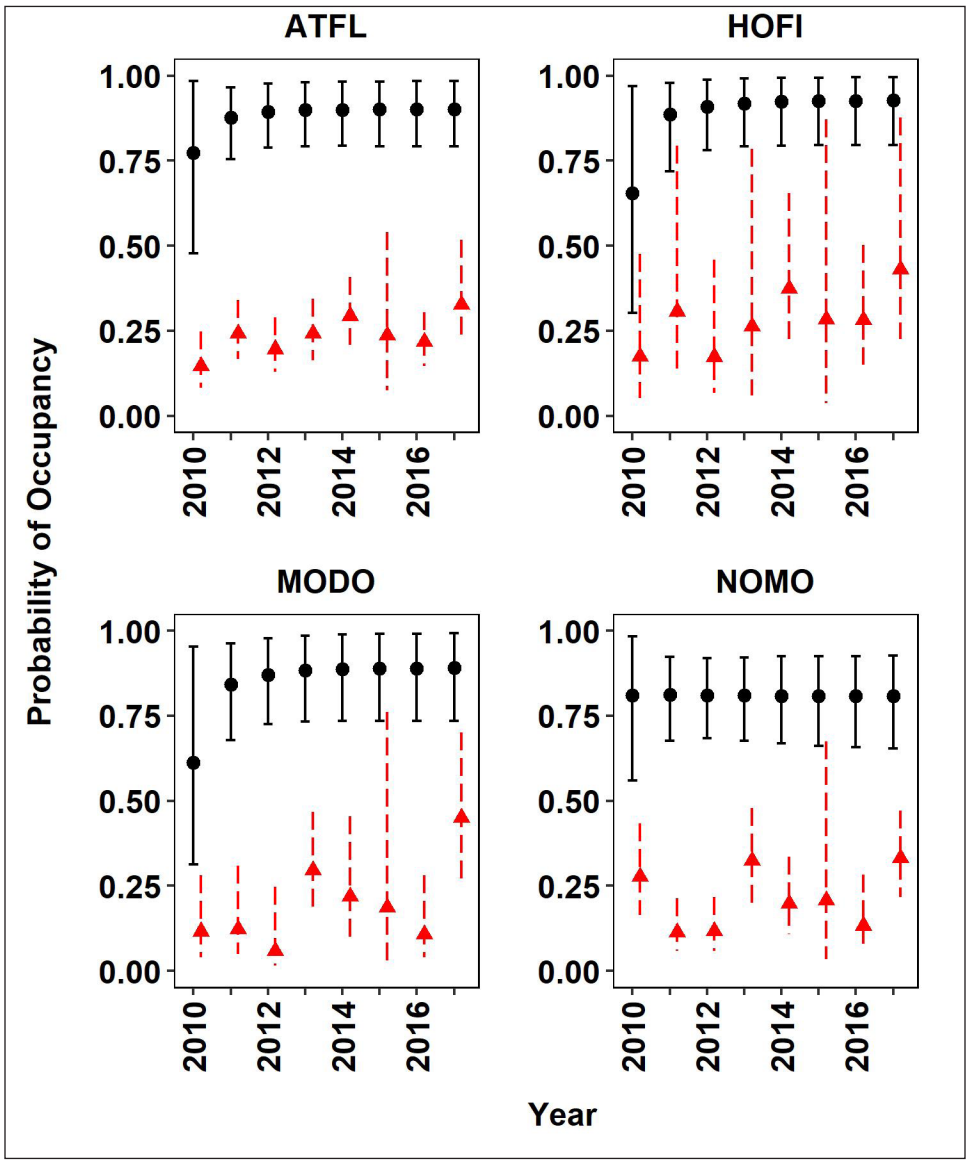


Figure D-11. Estimated probability of occupancy, for members of the upland generalist breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from Big Bend NP upland surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. Species codes available in appendix table.

Grassland breeding habitat guild

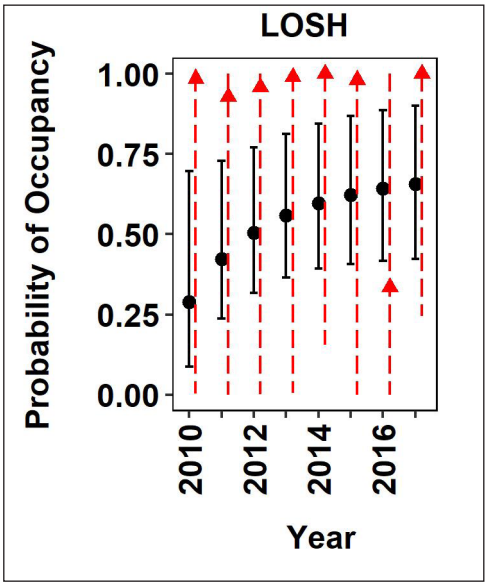


Figure D-12. Estimated probability of occupancy, for a member of the grassland breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from Big Bend NP upland surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. LOSH = Loggerhead Shrike.

Riparian/wetland breeding habitat guild

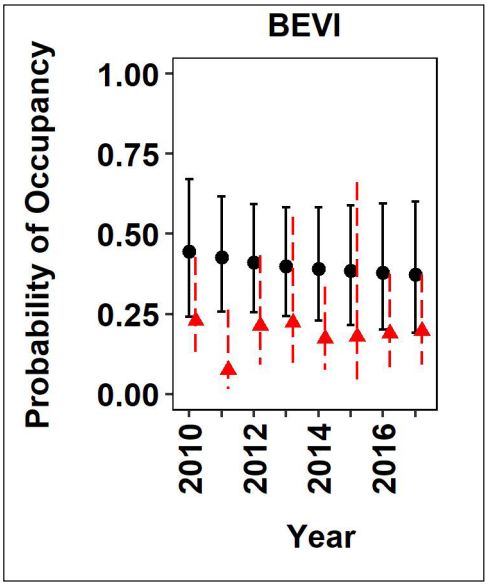


Figure D-13. Estimated probability of occupancy for a member of the riparian/wetland breeding habitat guild, by year, for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from Big Bend NP upland surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. BEVI = Bell's Vireo.

Shrubland breeding habitat guild

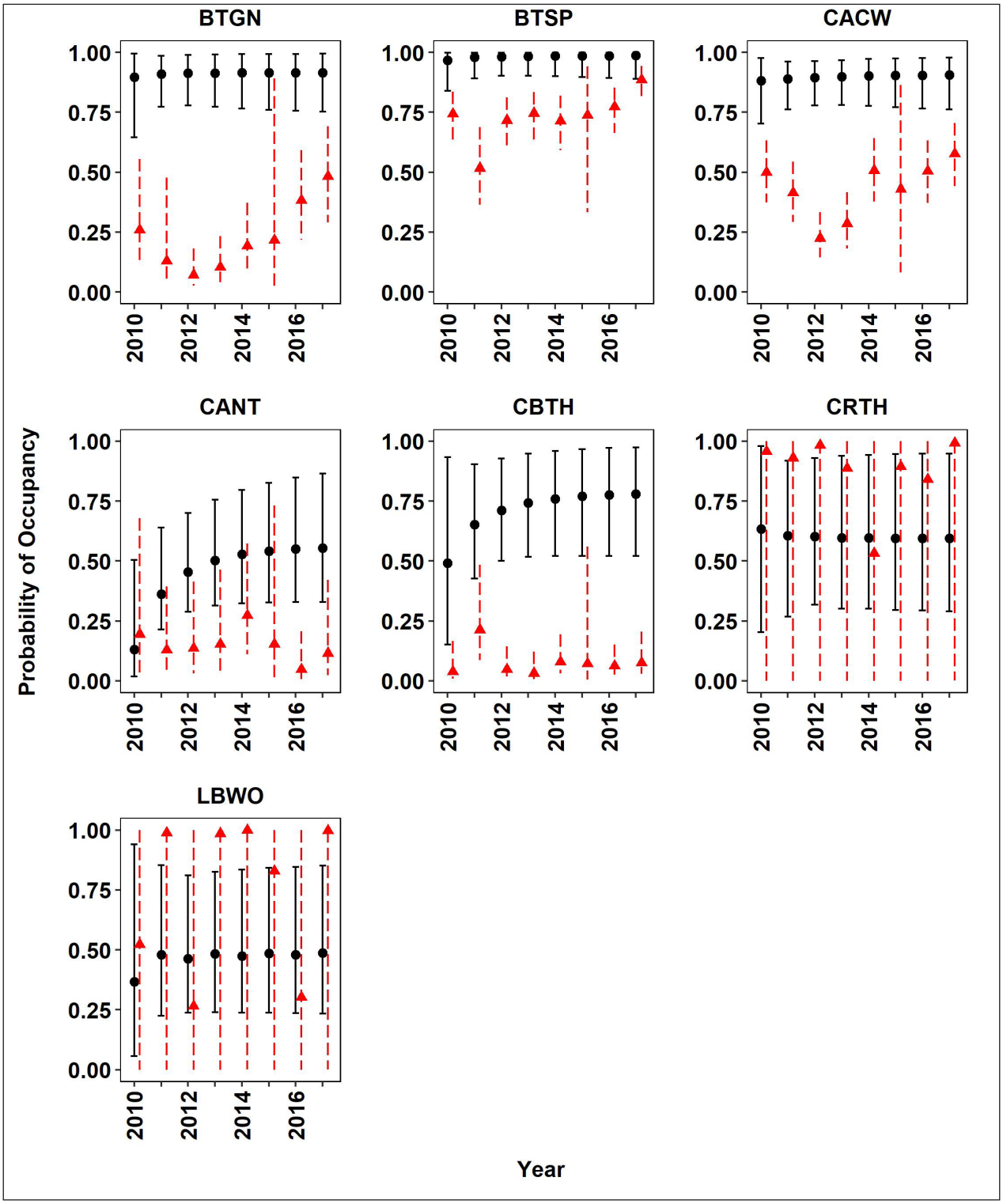


Figure D-14a. Estimated probability of occupancy, for members of the shrubland breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from Big Bend NP upland surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. Species codes available in appendix table.

Shrubland breeding habitat guild....continued

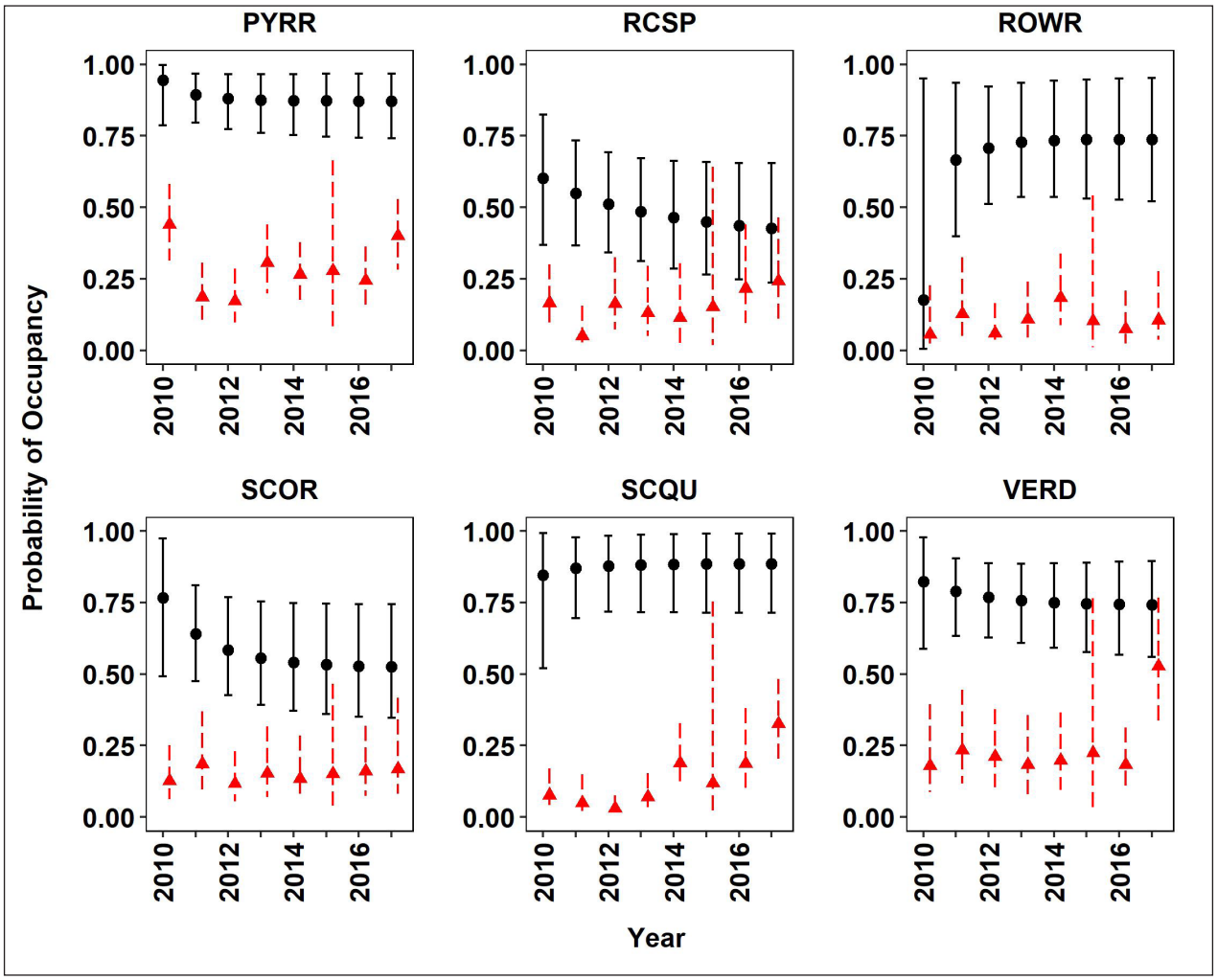


Figure D-14b. Estimated probability of occupancy, for more members of the shrubland breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from Big Bend NP upland surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. Species codes available in appendix table.

D.4 Big Bend NP Riparian Habitat

Upland generalist breeding habitat guild

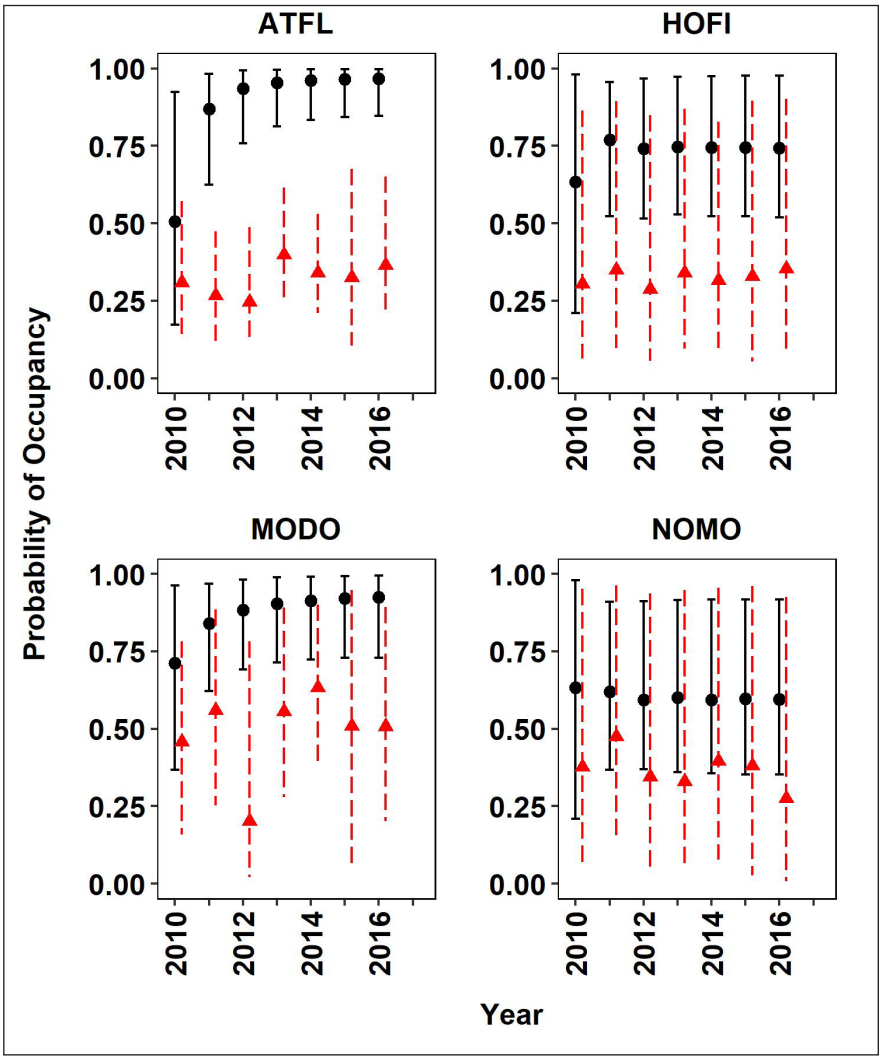


Figure D-15. Estimated probability of occupancy, for members of the upland generalist breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from Big Bend NP riparian surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. Species codes available in appendix table.

Shrubland breeding habitat guild

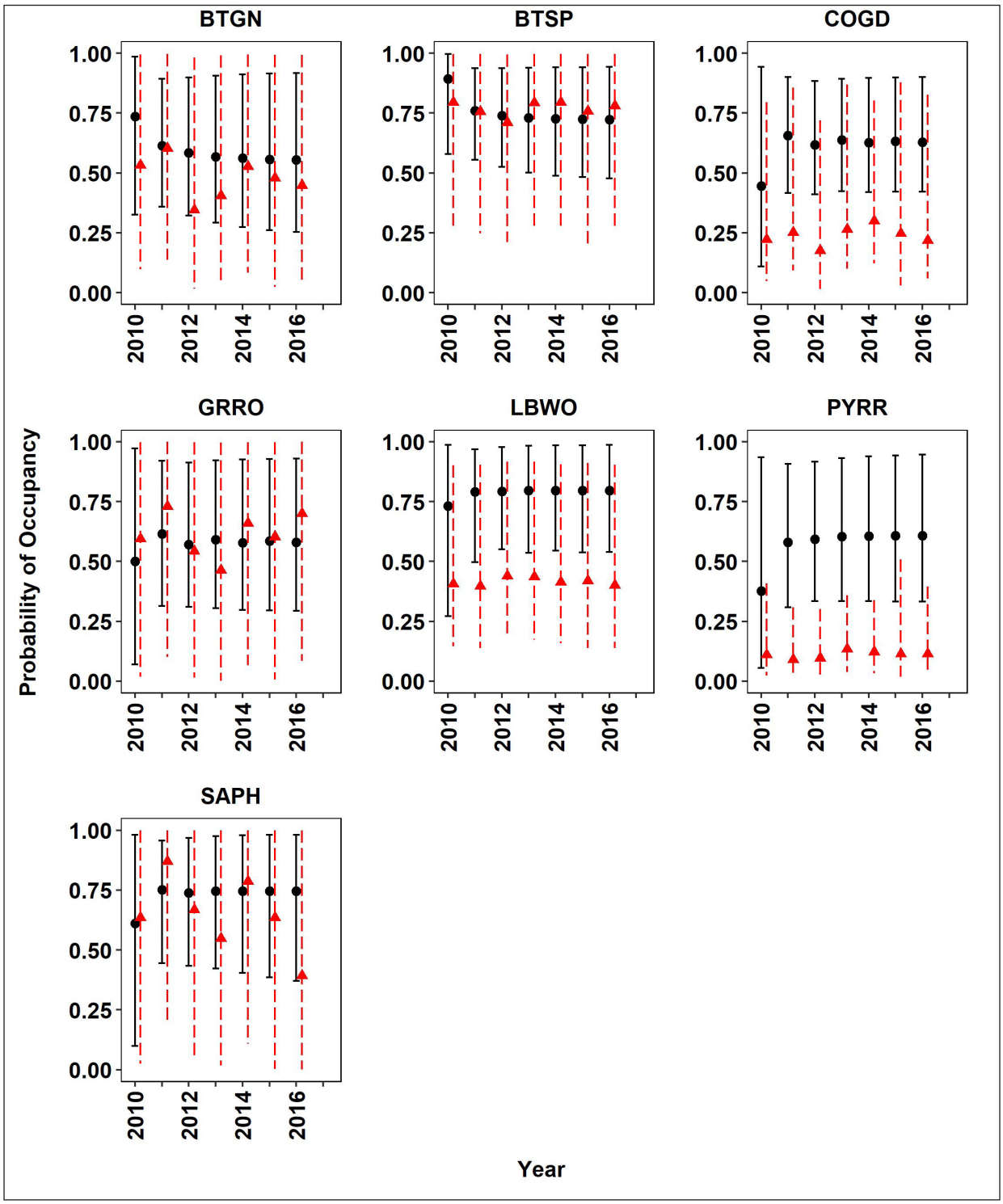


Figure D-16. Estimated probability of occupancy, for members of the shrubland breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from Big Bend NP riparian habitat surveyed. Symbol = Bayesian posterior median, error bars = 95% credible interval. Species codes available in appendix table.

Grassland breeding habitat guild

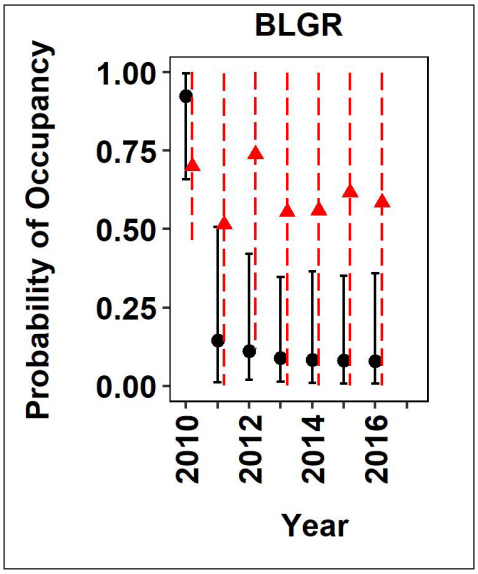


Figure D-17. Estimated probability of occupancy, for a member of the grassland breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from Big Bend NP riparian surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. BLGR = Blue Grosbeak.

Woodland breeding habitat guild

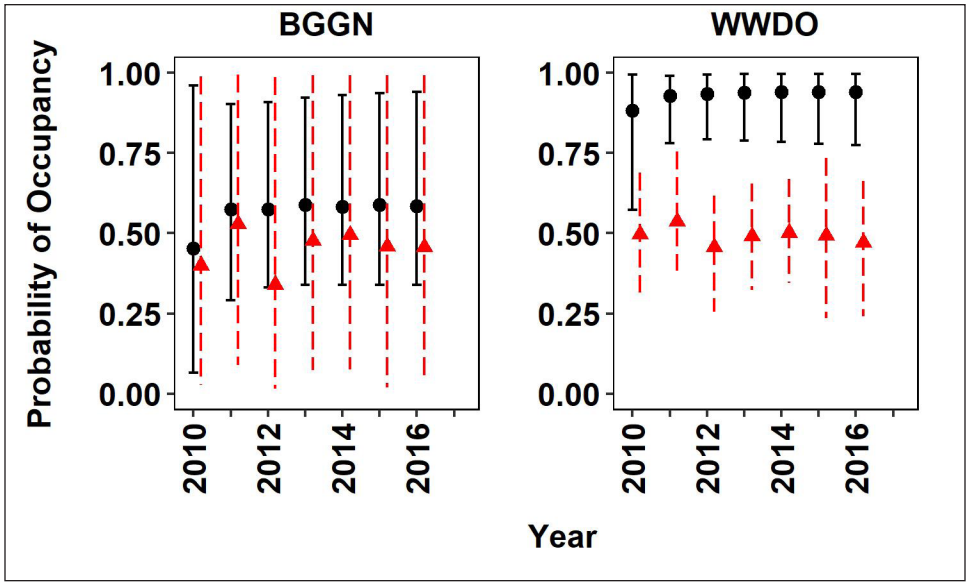


Figure D-18. Estimated probability of occupancy, for members of the woodland breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from Big Bend NP riparian surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. BGGN = Blue-gray Gnatcatcher, WWDO = White-winged Dove.

Riparian/wetland breeding habitat guild

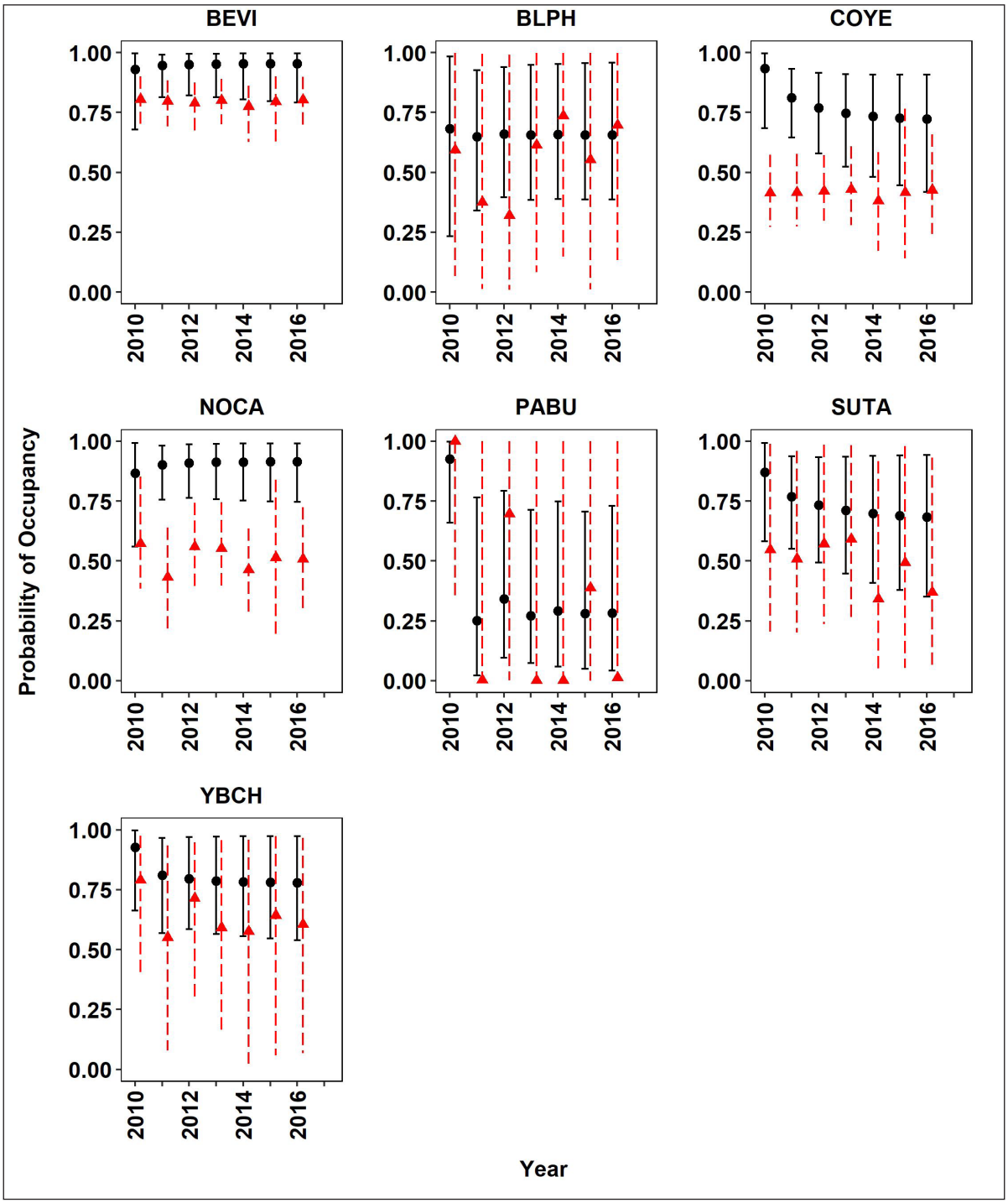


Figure D-19. Estimated probability of occupancy, for members of the riparian/wetland breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from Big Bend NP riparian surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. Species codes available in appendix table.

D.5 Carlsbad Caverns NP Upland Habitat

Upland generalist breeding habitat guild

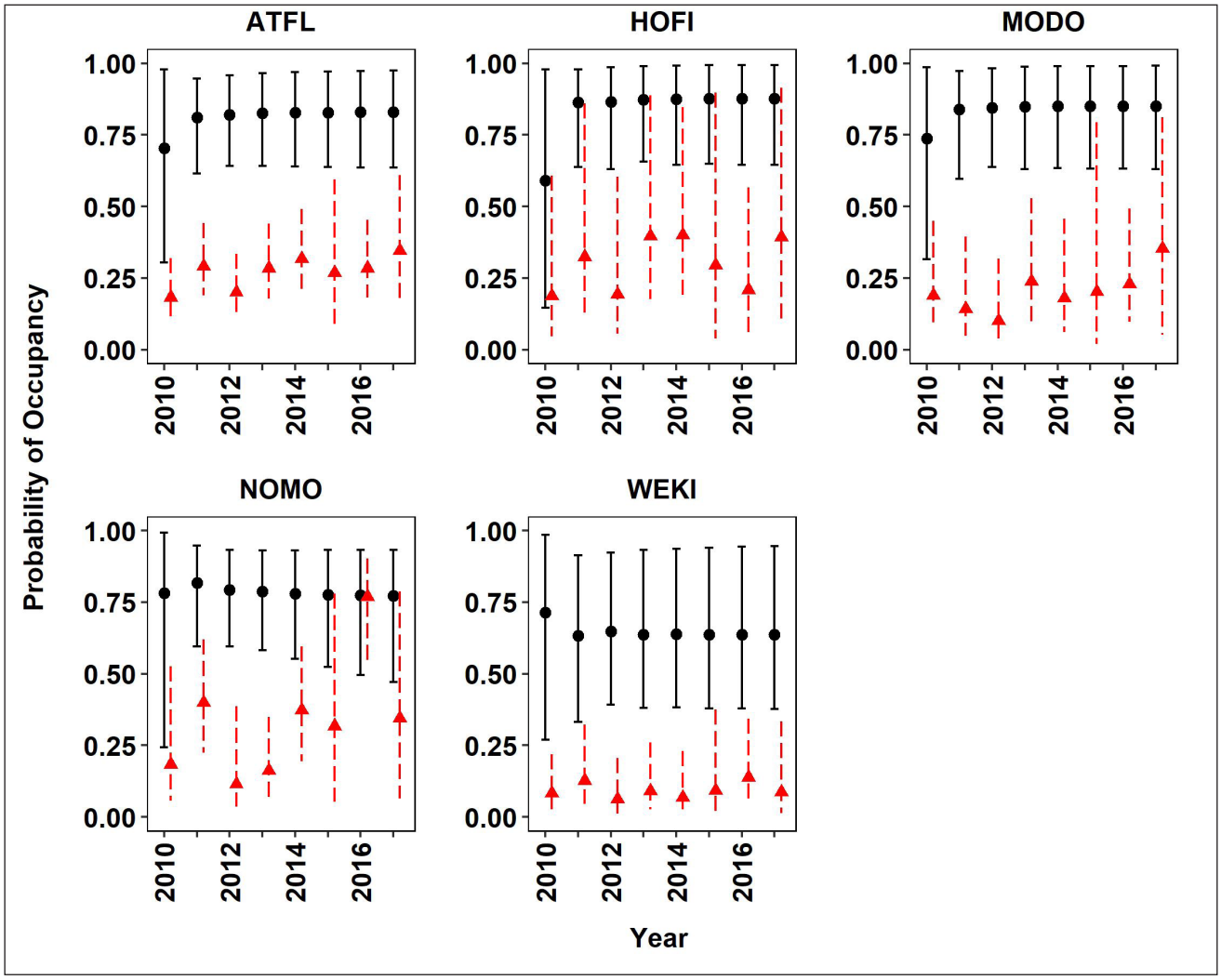


Figure D-20. Estimated probability of occupancy, for members of the upland generalist breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from Carlsbad Caverns NP upland surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. Species codes available in appendix table.

Grassland breeding habitat guild

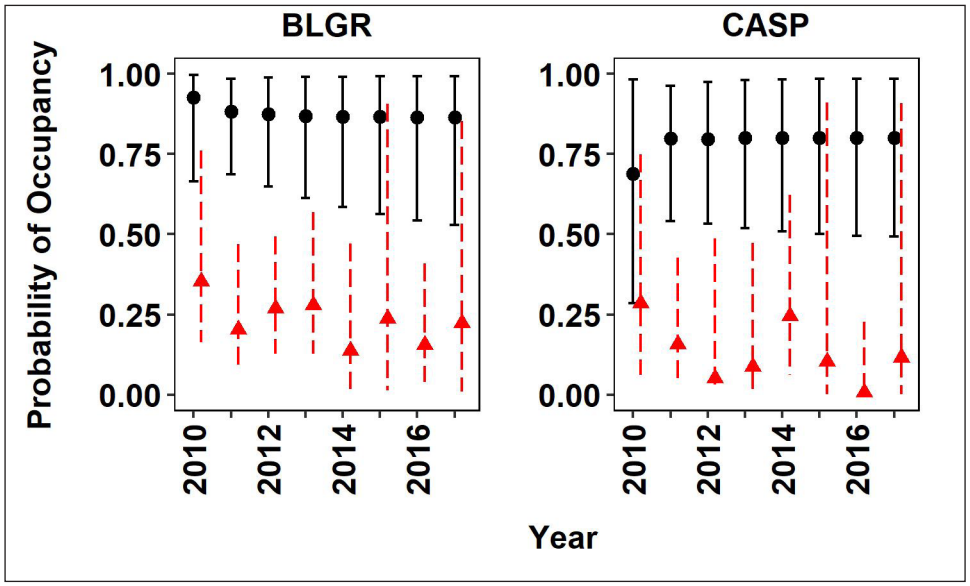


Figure D-21. Estimated probability of occupancy, for members of the grassland breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from Carlsbad Caverns NP upland surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. BLGR = Blue Grosbeak, CASP = Cassin's Sparrow.

Woodland breeding habitat guild

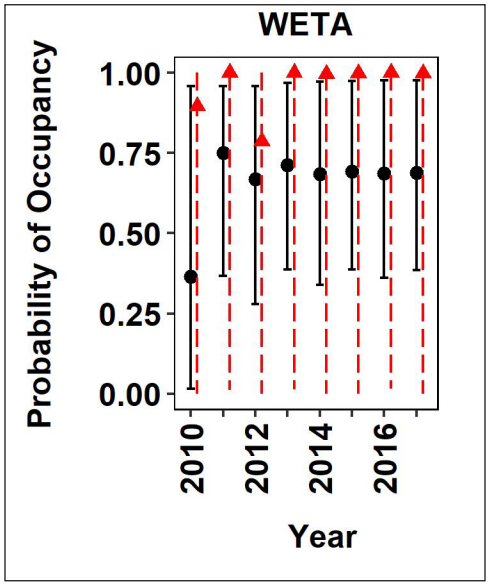


Figure D-22. Estimated probability of occupancy, for a member of the woodland breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from Carlsbad Caverns NP upland surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. WETA = Western Tanager.

Shrubland breeding habitat guild

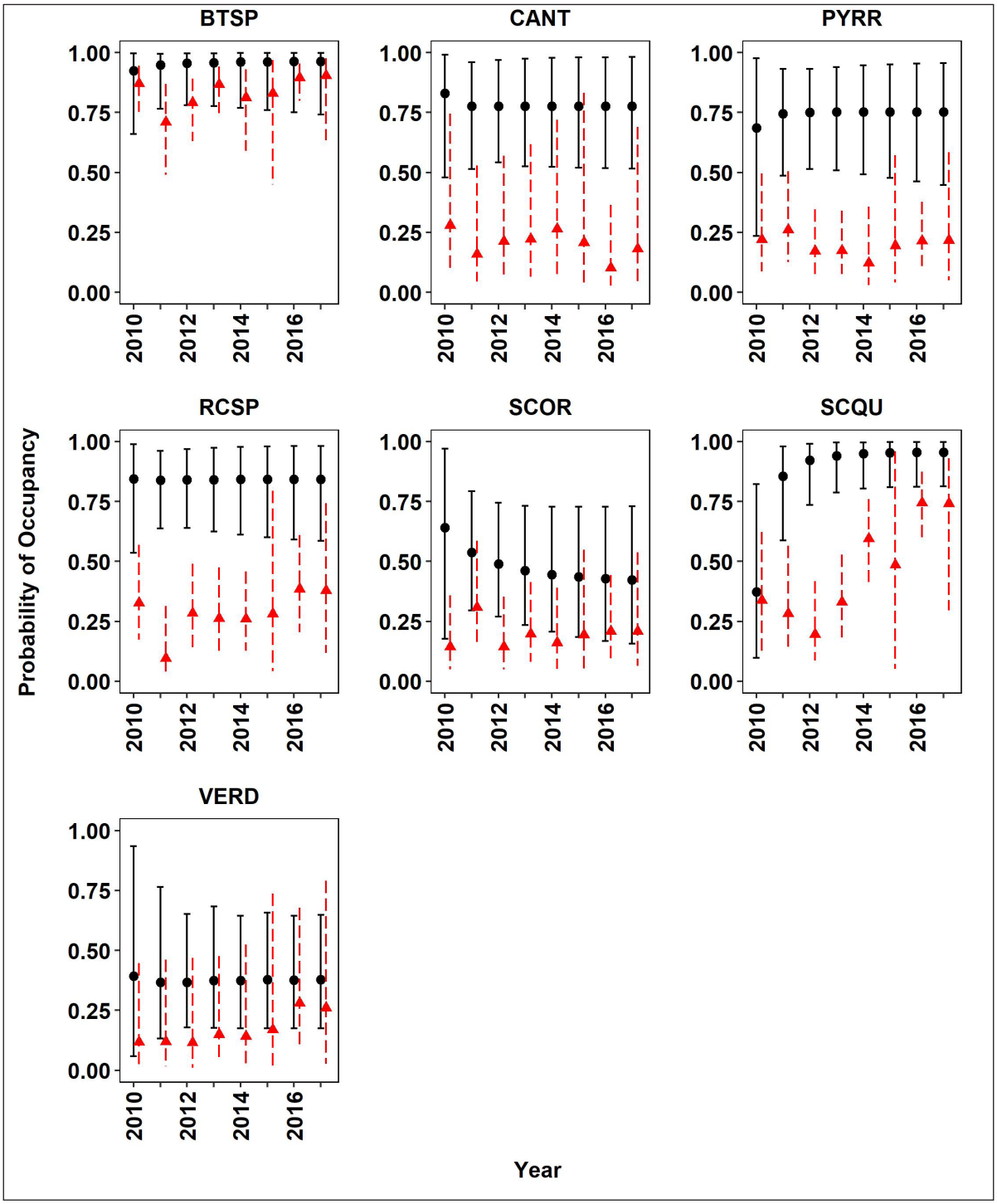


Figure D-23. Estimated probability of occupancy, for members of the shrubland breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from Carlsbad Caverns NP upland surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. Species codes available in appendix table.

D.6 Carlsbad Caverns NP Riparian Habitat

Upland generalist breeding habitat guild

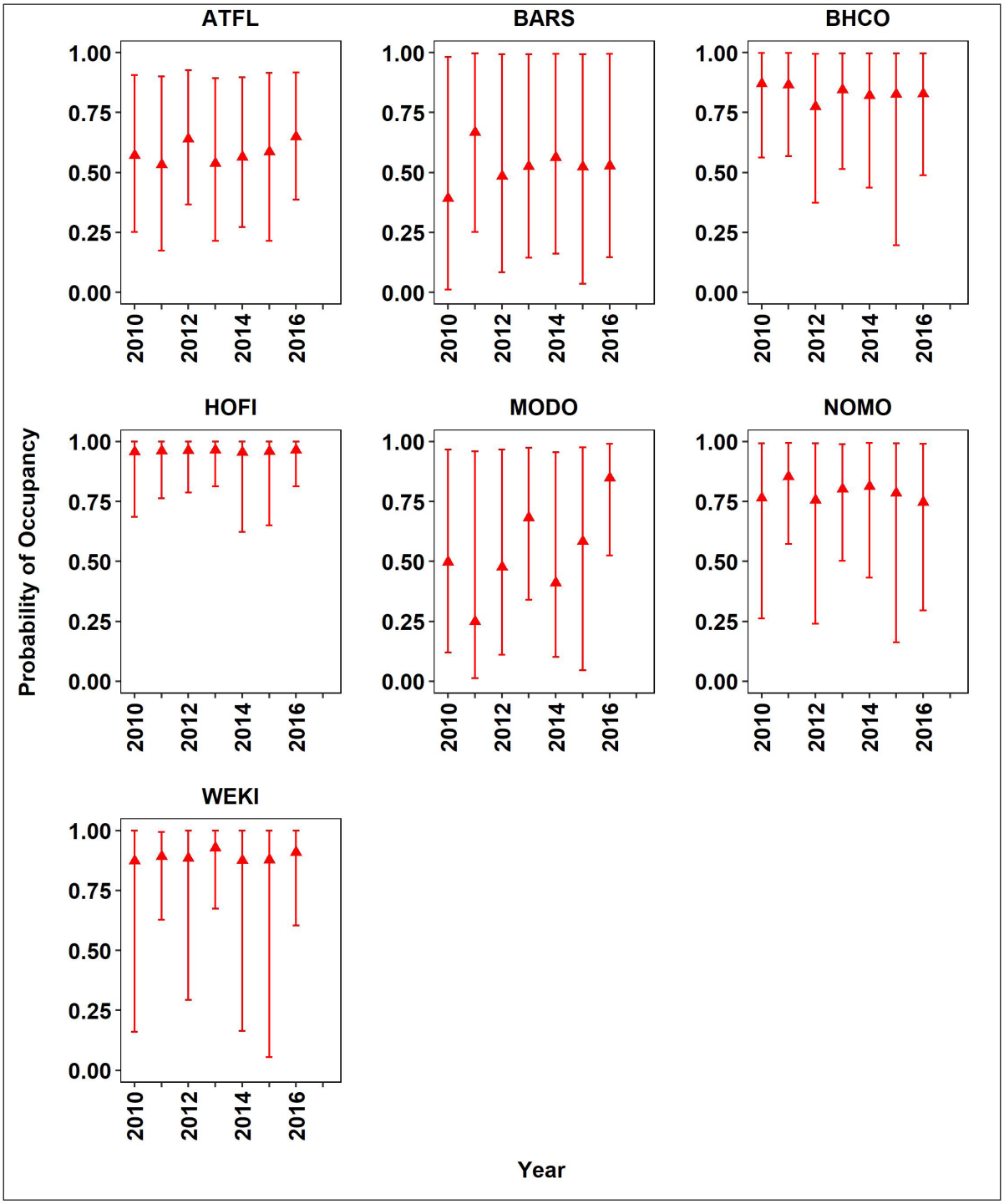


Figure D-24. Estimated probability of occupancy, for members of the upland generalist breeding habitat guild, by year for points (unconditional point occupancy) from Carlsbad Caverns NP riparian surveys. Because there was only one transect in this park-habitat, occupancy was estimated only at the point scale. Symbol = Bayesian posterior median, error bars = 95% credible interval. Species codes available in appendix table.

Grassland breeding habitat guild

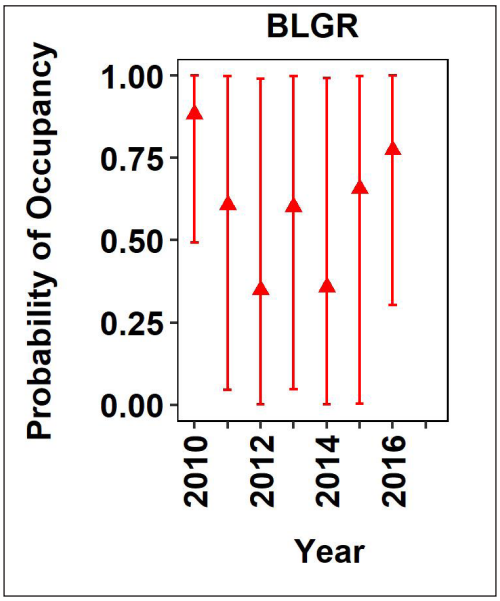


Figure D-25. Estimated probability of occupancy, for a member of the grassland breeding habitat guild, by year for points (unconditional point occupancy) from Carlsbad Caverns NP riparian surveys. Because there was only one transect in this park-habitat, occupancy was estimated only at the point scale. Symbol = Bayesian posterior median, error bars = 95% credible interval. BLGR = Blue Grosbeak.

Shrubland breeding habitat guild

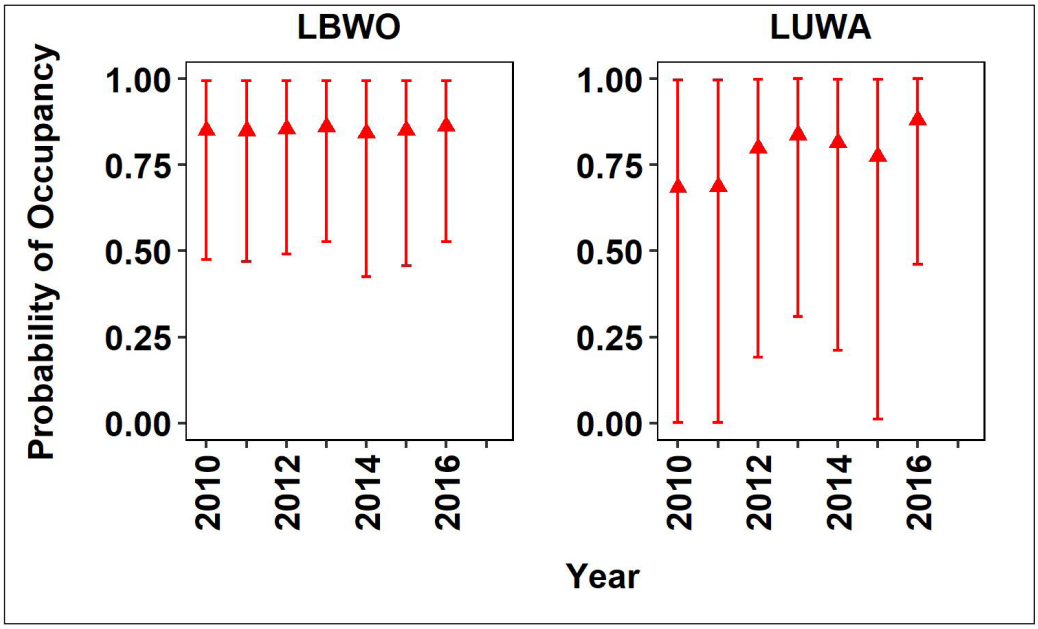


Figure D-26. Estimated probability of occupancy, for members of the shrubland breeding habitat guild, by year for points (unconditional point occupancy) from Carlsbad Caverns NP riparian surveys. Because there was only one transect in this park-habitat, occupancy was estimated only at the point scale. Symbol = Bayesian posterior median, error bars = 95% credible interval. LBWO = Ladder-backed Woodpecker, LUWA = Lucy's Warbler.

Woodland breeding habitat guild

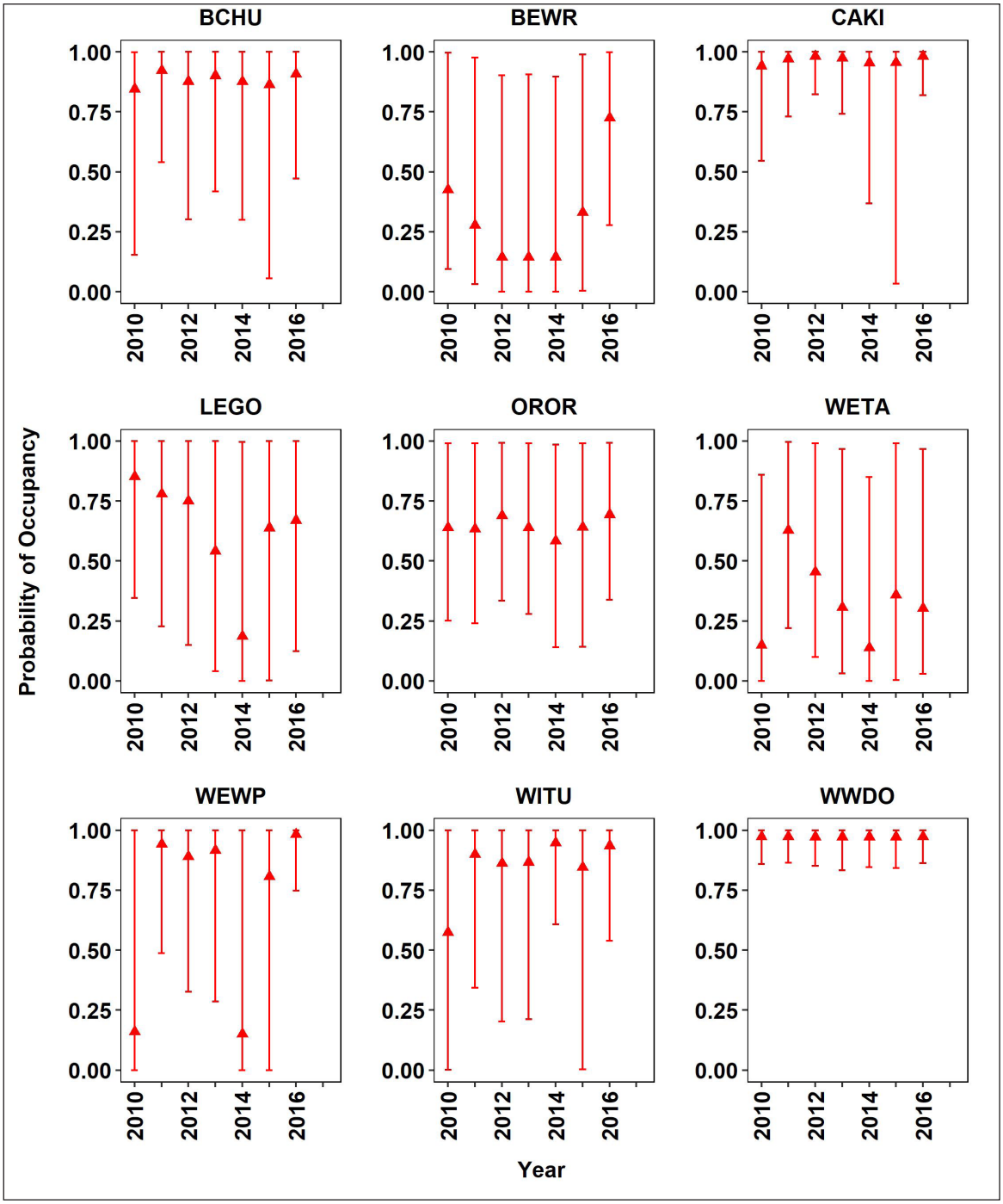


Figure D-27. Estimated probability of occupancy, for members of the woodland breeding habitat guild, by year for points (unconditional point occupancy) from Carlsbad Caverns NP riparian surveys. Because there was only one transect in this park-habitat, occupancy was estimated only at the point scale. Symbol = Bayesian posterior median, error bars = 95% credible interval. Species codes available in appendix table.

Riparian/wetland breeding habitat guild

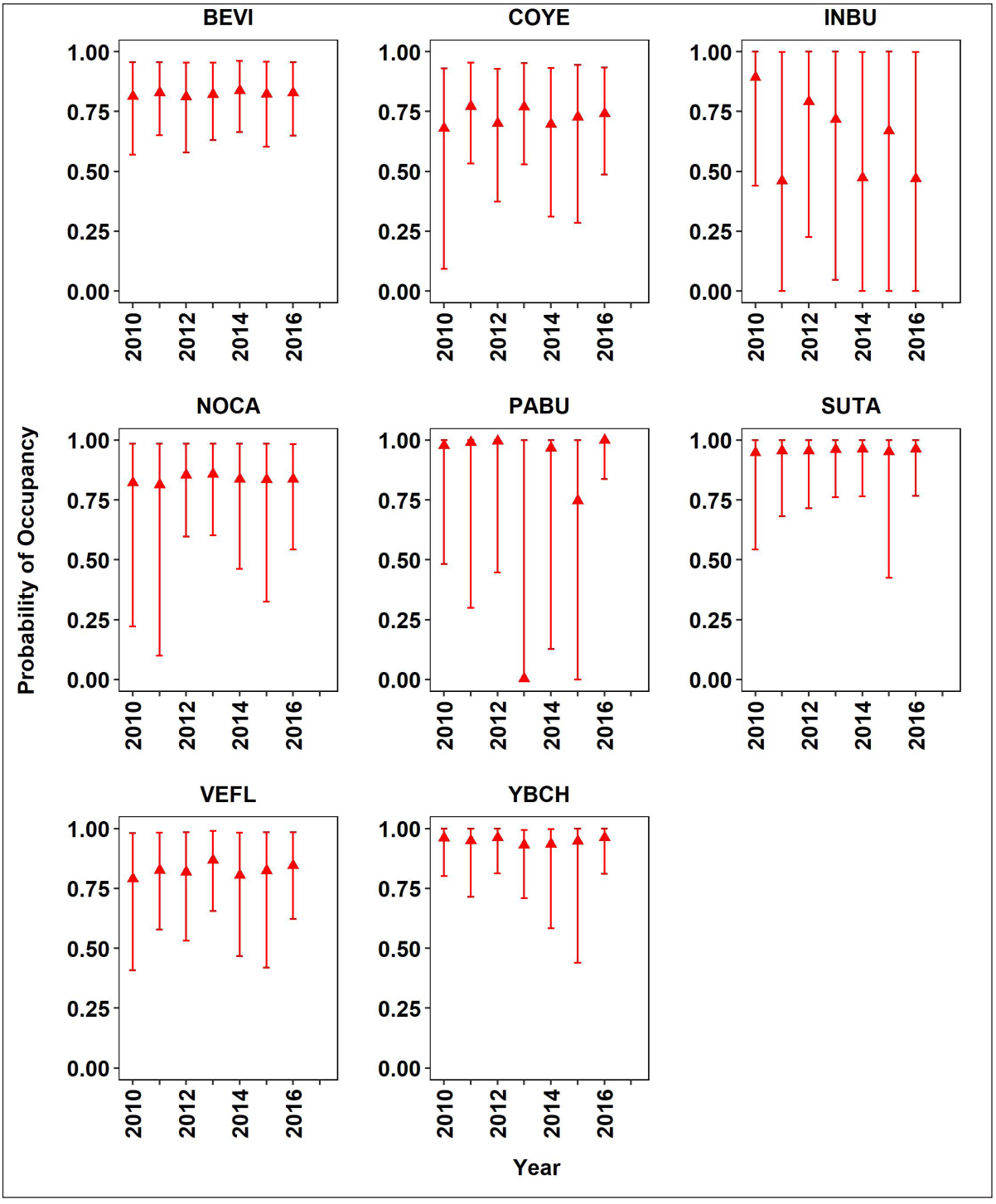


Figure D-28. Estimated probability of occupancy, for members of the riparian/wetland breeding habitat guild, by year for points (unconditional point occupancy) from Carlsbad Caverns NP riparian surveys. Because there was only one transect in this park-habitat, occupancy was estimated only at the point scale. Symbol = Bayesian posterior median, error bars = 95% credible interval. Species codes available in appendix table.

D.7 Fort Davis National Historic Site (NHS) Upland Habitat

Upland generalist breeding habitat guild

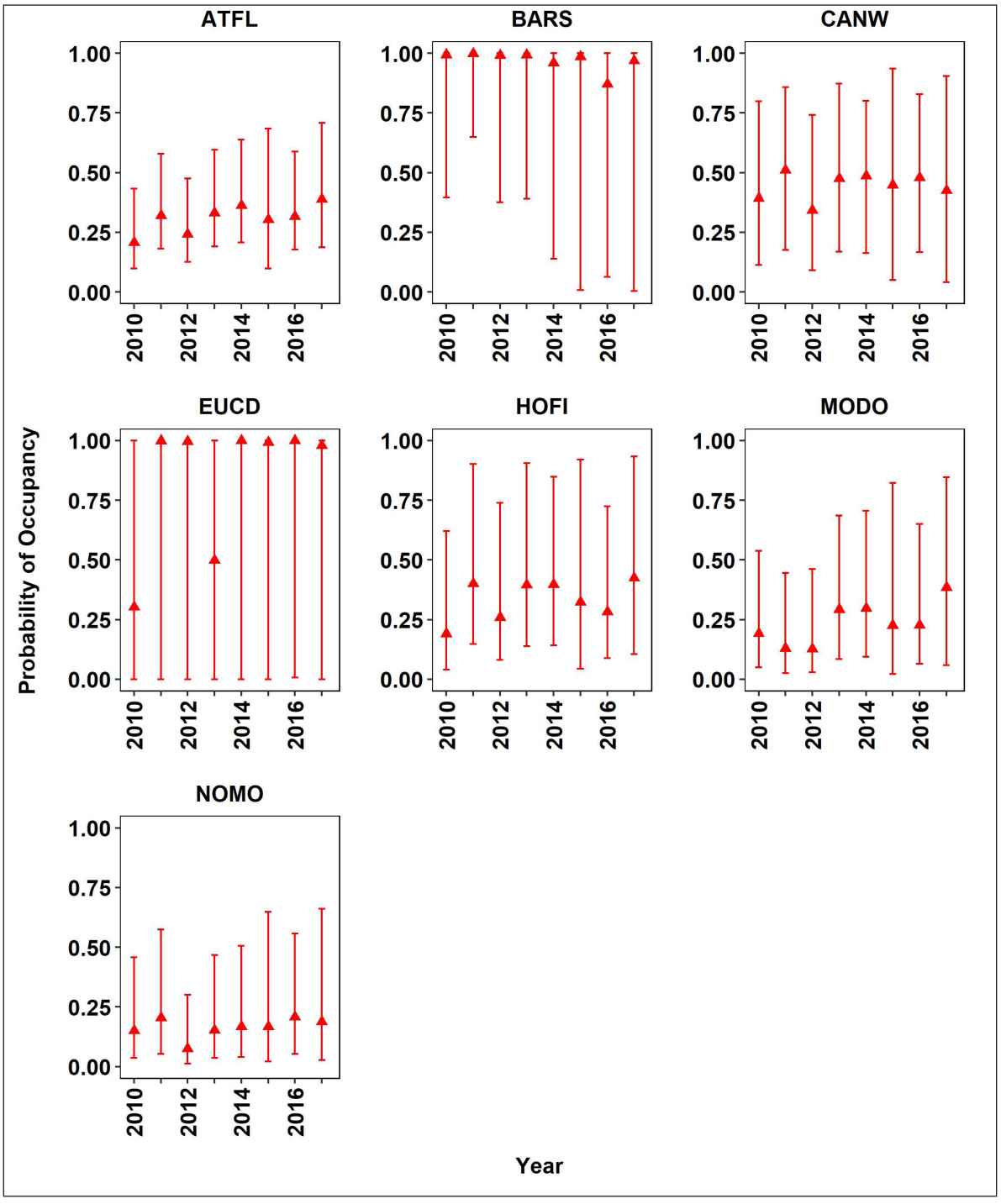


Figure D-29. Estimated probability of occupancy, for members of the upland generalist breeding habitat guild, by year for points (unconditional point occupancy) from Fort Davis NHS upland surveys. Because there was only one transect in this park-habitat, occupancy was estimated only at the point scale. Symbol = Bayesian posterior median, error bars = 95% credible interval. Species codes available in appendix table.

Grassland breeding habitat guild

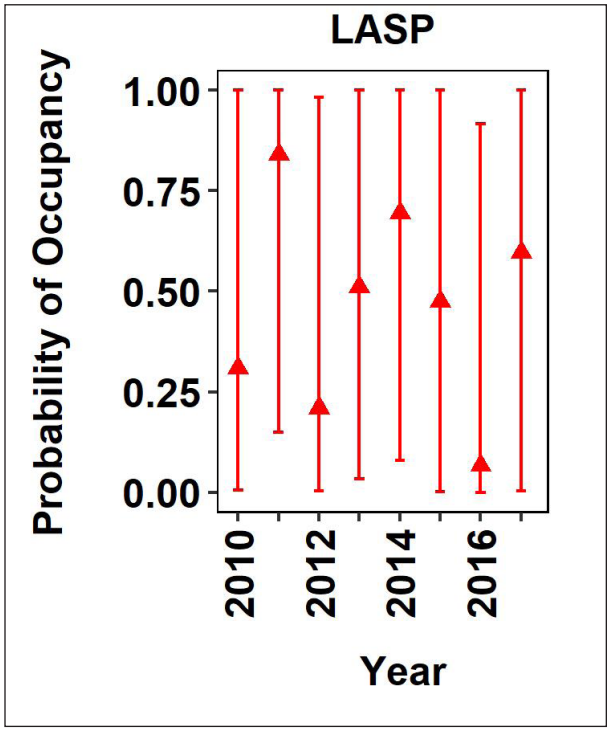


Figure D-30. Estimated probability of occupancy, for a member of the grassland breeding habitat guild, by year for points (unconditional point occupancy) from Fort Davis NHS upland surveys. Because there was only one transect in this park-habitat, occupancy was estimated only at the point scale. Symbol = Bayesian posterior median, error bars = 95% credible interval. LASP = Lark Sparrow.

Shrubland breeding habitat guild

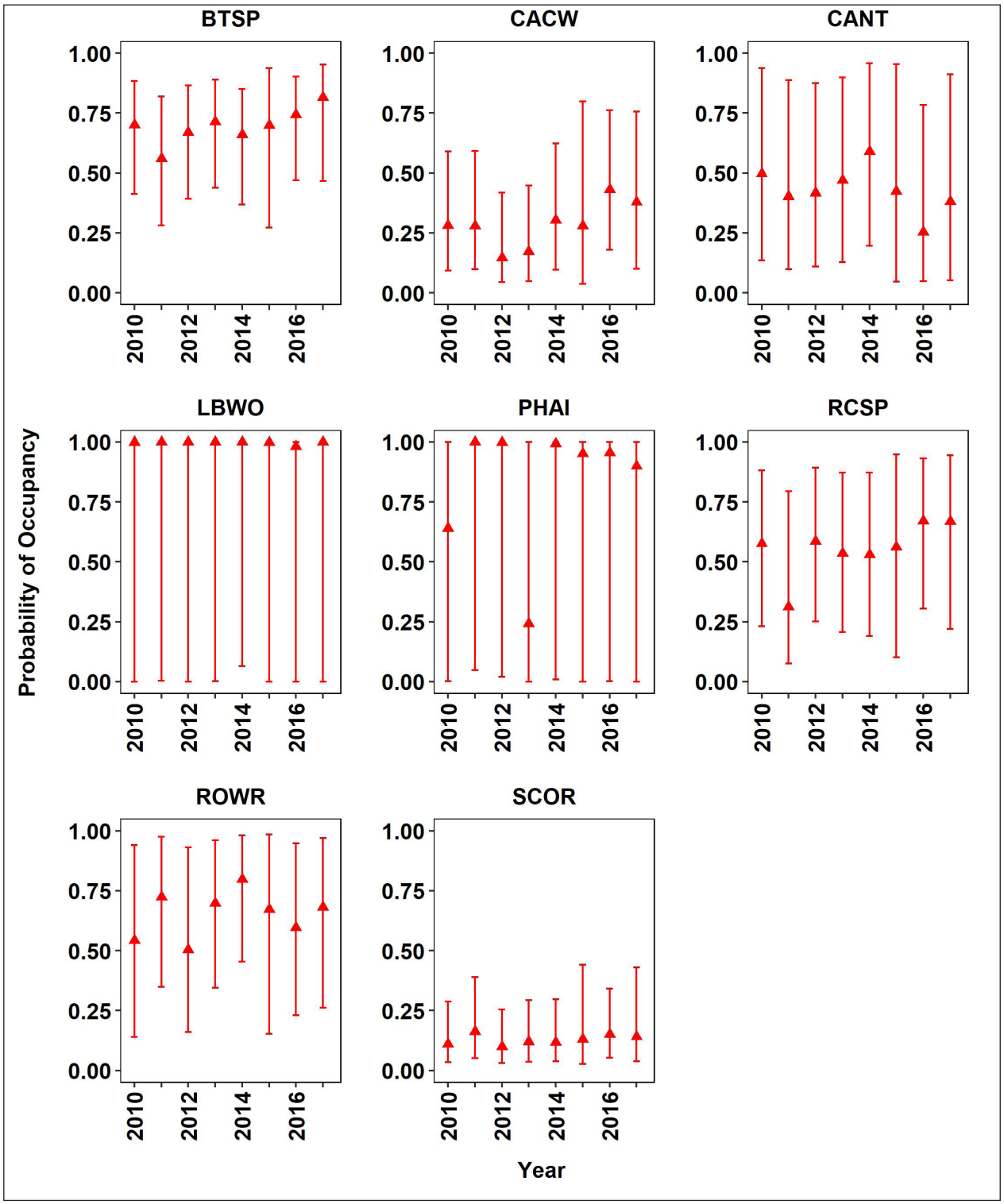


Figure D-31. Estimated probability of occupancy, for members of the shrubland breeding habitat guild, by year for points (unconditional point occupancy) from Fort Davis NHS upland surveys. Because there was only one transect in this park-habitat, occupancy was estimated only at the point scale. Symbol = Bayesian posterior median, error bars = 95% credible interval. Species codes available in appendix table.

Woodland breeding habitat guild

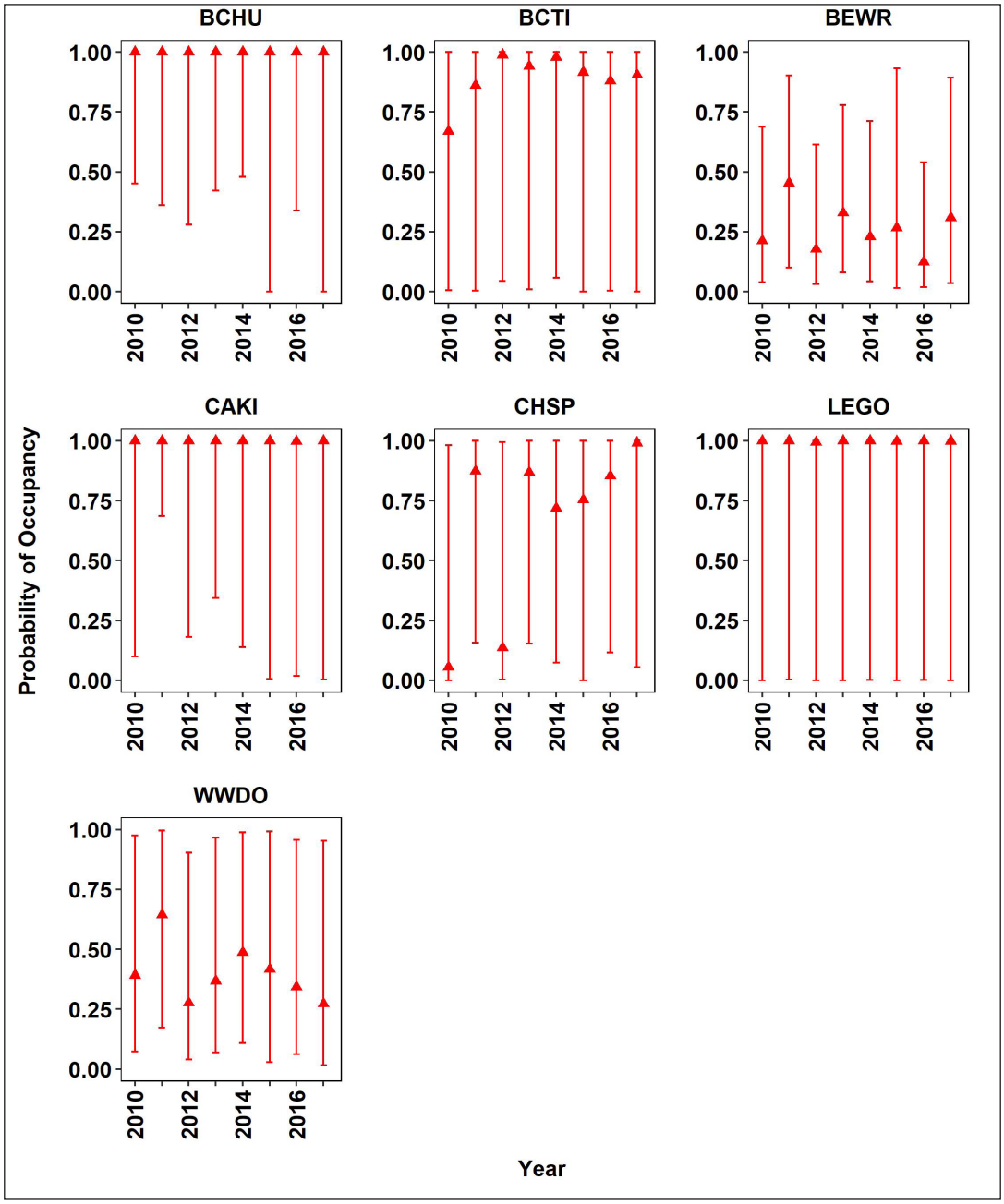


Figure D-32. Estimated probability of occupancy, for members of the woodland generalist breeding habitat guild, by year for points (unconditional point occupancy) from Fort Davis NHS upland surveys. Because there was only one transect in this park-habitat, occupancy was estimated only at the point scale. Symbol = Bayesian posterior median, error bars = 95% credible interval. Species codes available in appendix table.

D.8 Guadalupe Mountains NP Upland Habitat

Upland generalist breeding habitat guild

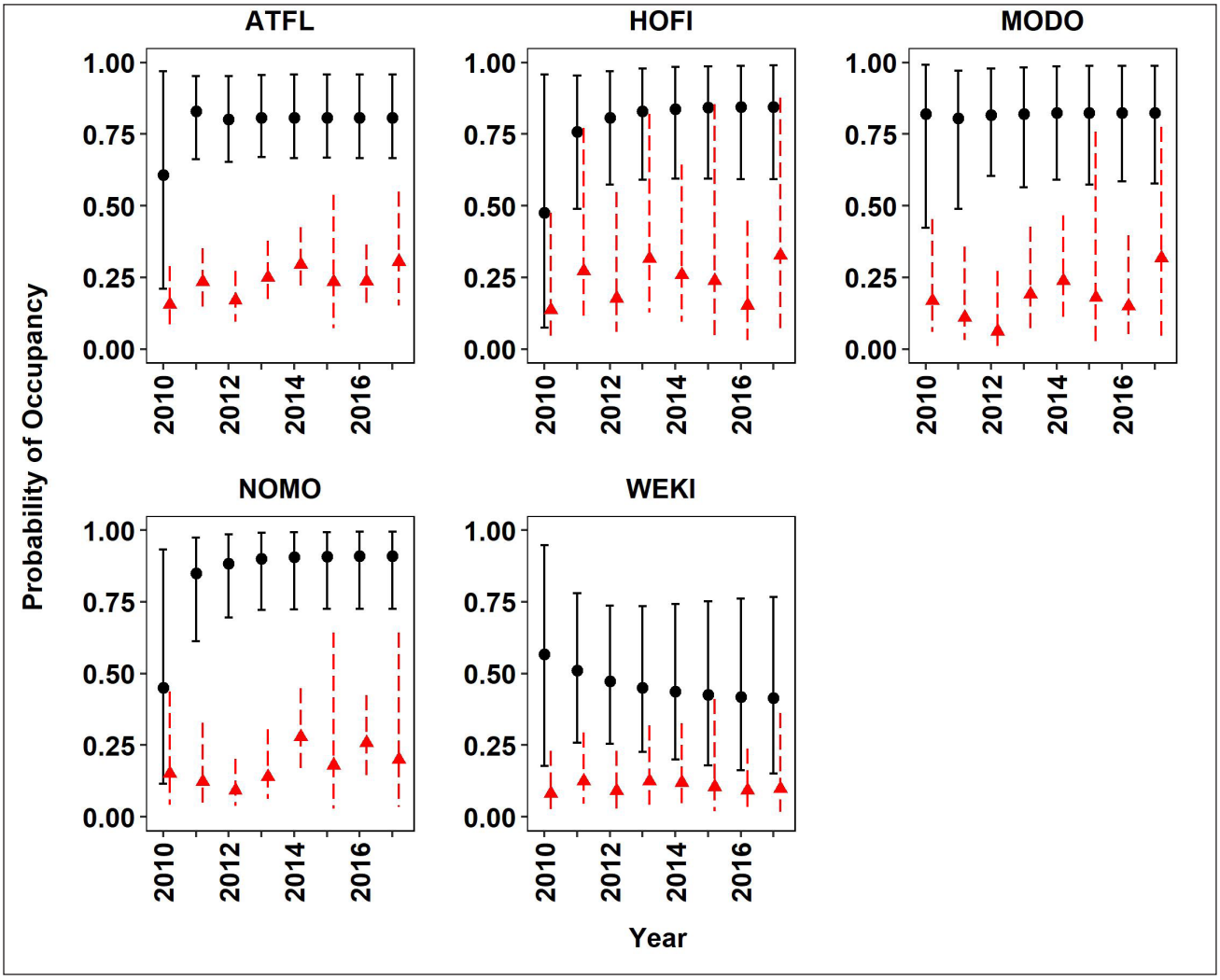


Figure D-33. Estimated probability of occupancy, for members of the upland generalist breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from Guadalupe Mountains NP upland surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. Species codes available in appendix table.

Grassland breeding habitat guild

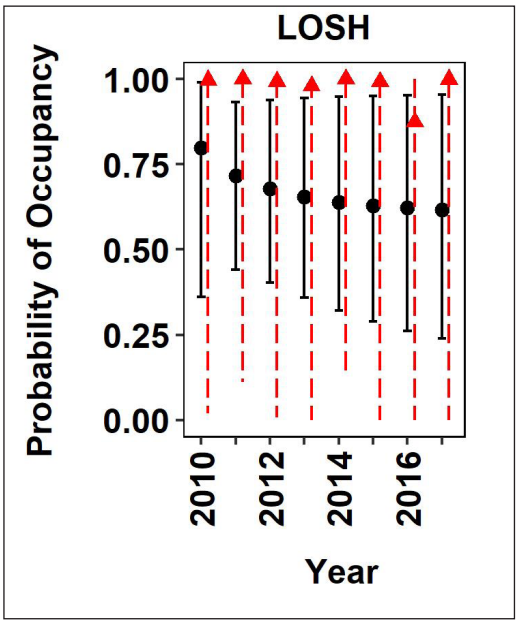


Figure D-34. Estimated probability of occupancy, for a member of the grassland breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from Guadalupe Mountains NP upland surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. LOSH = Loggerhead Shrike.

Woodland breeding habitat guild

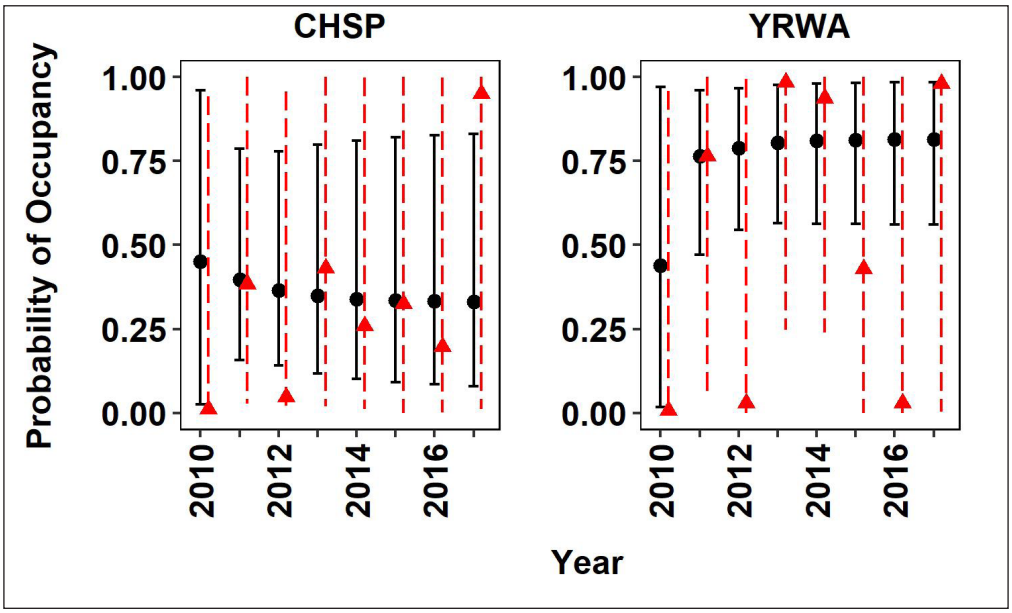


Figure D-35. Estimated probability of occupancy, for members of the woodland breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from Guadalupe Mountains NP upland surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. CHSP = Chipping Sparrow, YRWA = Yellow-rumped Warbler.

Shrubland breeding habitat guild

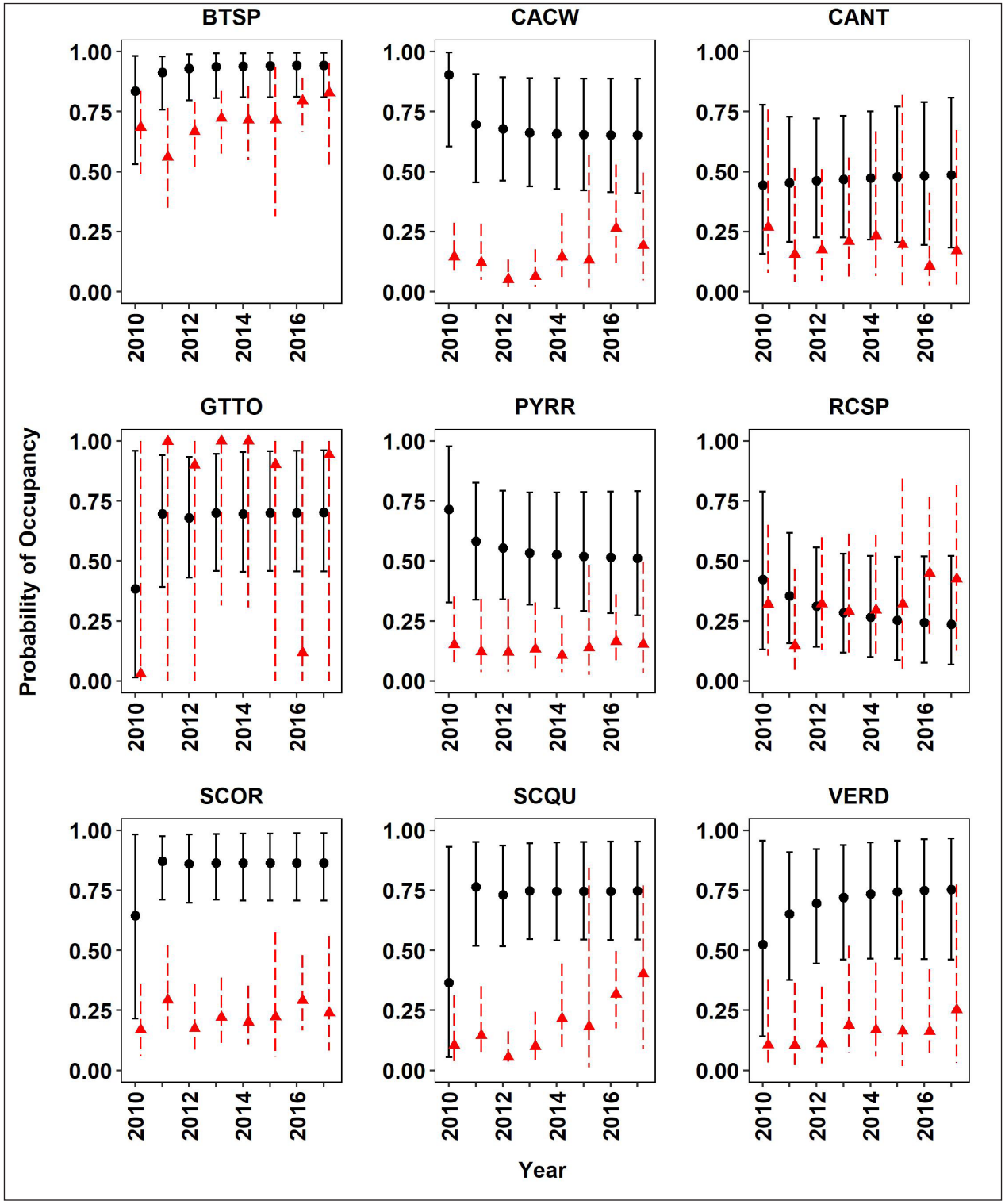


Figure D-36. Estimated probability of occupancy, for members of the shrubland breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from Guadalupe Mountains NP upland surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. Species codes available in appendix table.

D.9 Guadalupe Mountains NP Riparian Habitat

Upland generalist breeding habitat guild

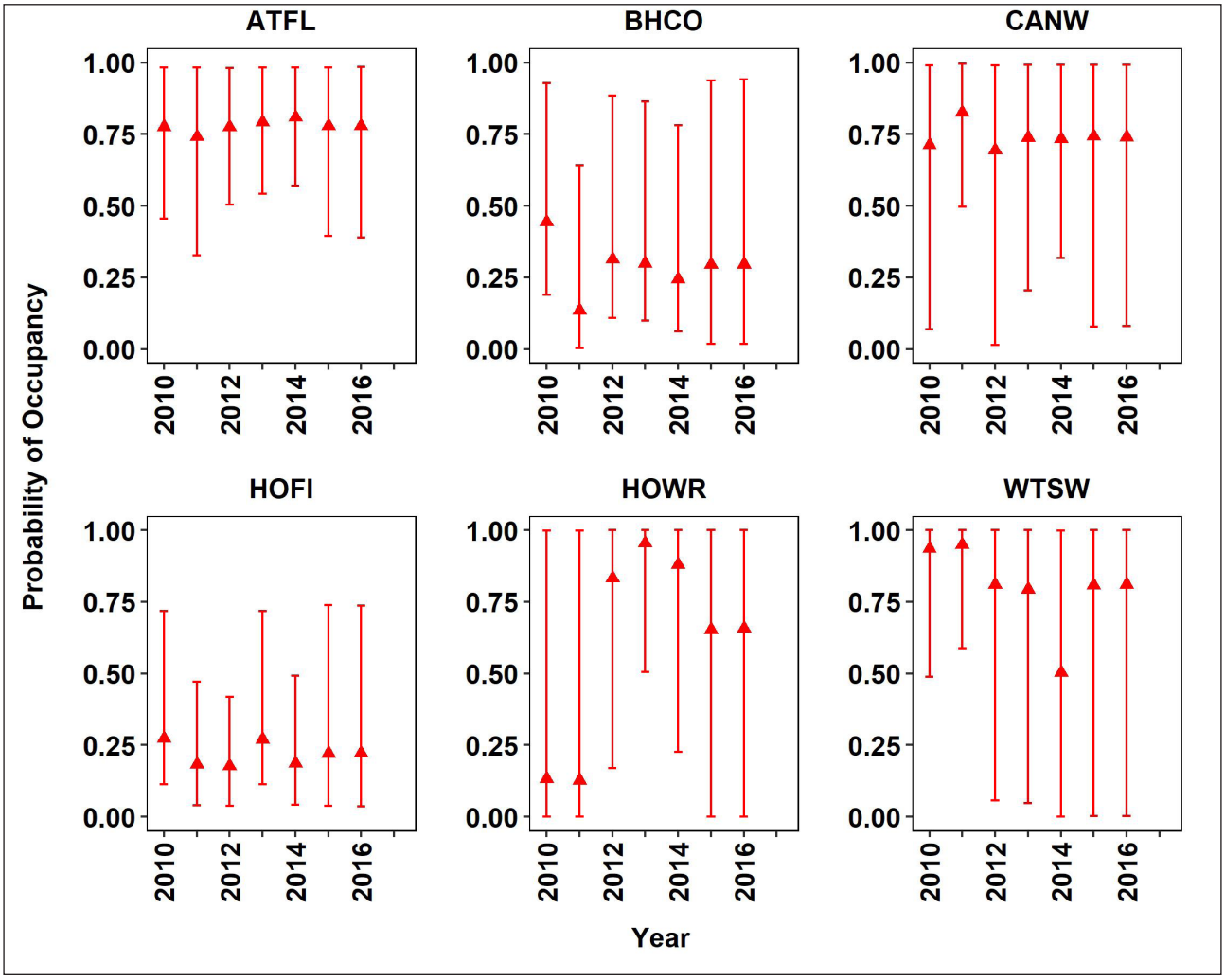


Figure D-37. Estimated probability of occupancy, for members of the upland generalist breeding habitat guild, by year for points (unconditional point occupancy) from Guadalupe Mountains NP riparian surveys. Because there was only one transect in this park-habitat, occupancy was estimated only at the point scale. Symbol = Bayesian posterior median, error bars = 95% credible interval. Species codes available in appendix table.

Shrubland breeding habitat guild

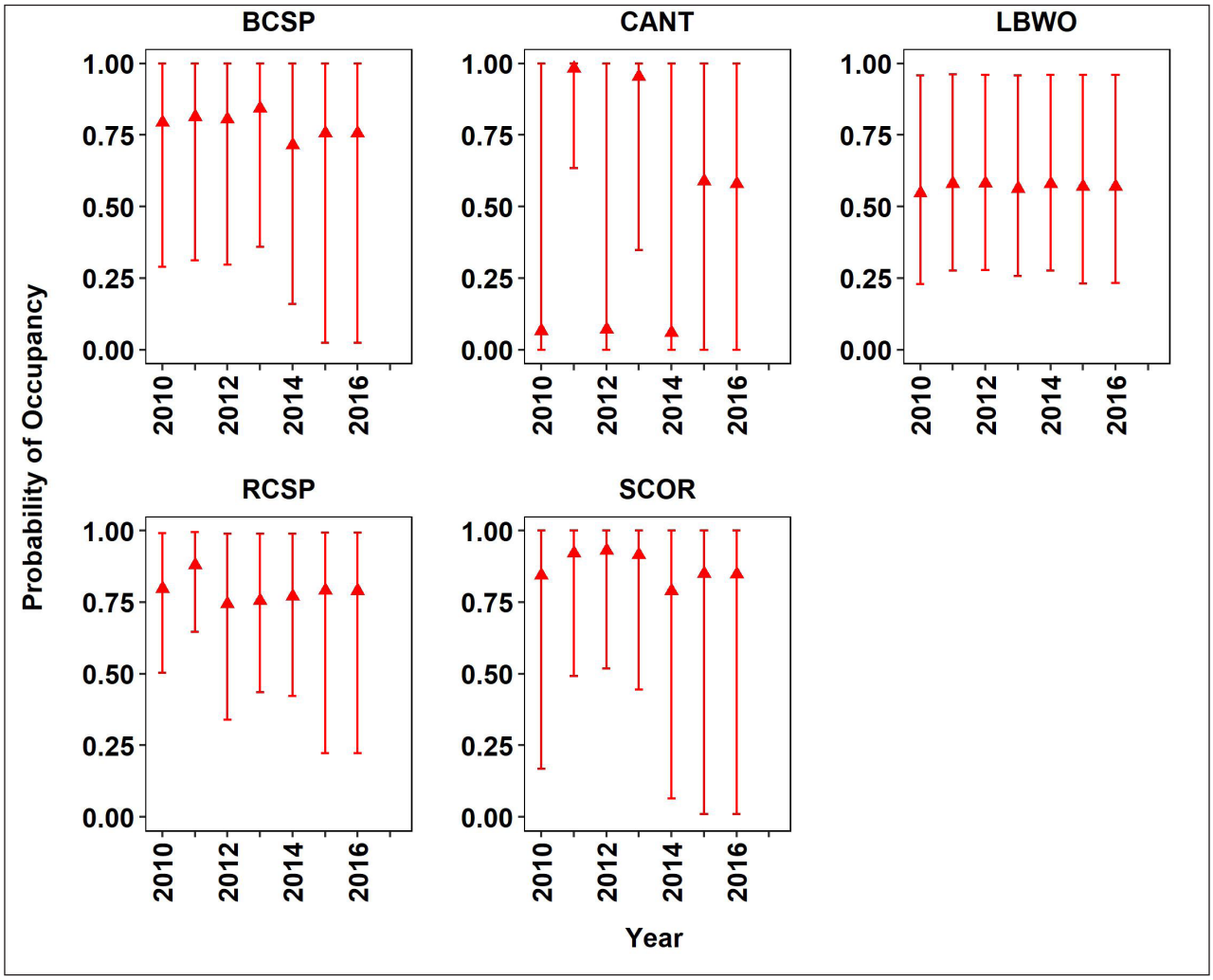


Figure D-38. Estimated probability of occupancy, for members of the shrubland breeding habitat guild, by year for points (unconditional point occupancy) from Guadalupe Mountains NP riparian surveys. Because there was only one transect in this park-habitat, occupancy was estimated only at the point scale. Symbol = Bayesian posterior median, error bars = 95% credible interval. Species codes available in appendix table.

Woodland breeding habitat guild

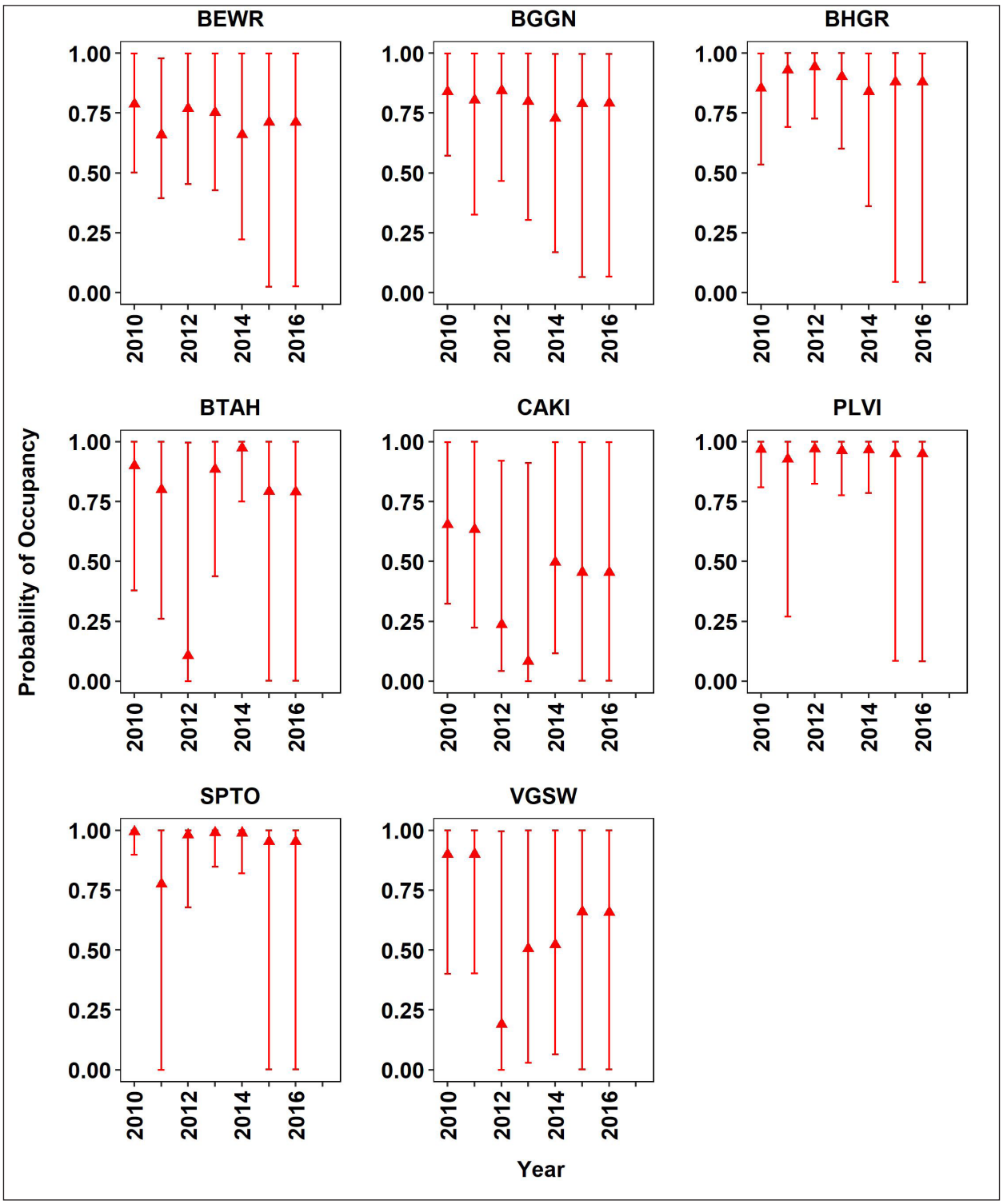


Figure D-39a. Estimated probability of occupancy, for members of the woodland breeding habitat guild, by year for points (unconditional point occupancy) from Guadalupe Mountains NP riparian surveys. Because there was only one transect in this park-habitat, occupancy was estimated only at the point scale. Symbol = Bayesian posterior median, error bars = 95% credible interval. Species codes available in appendix table.

Woodland breeding habitat guild...continued

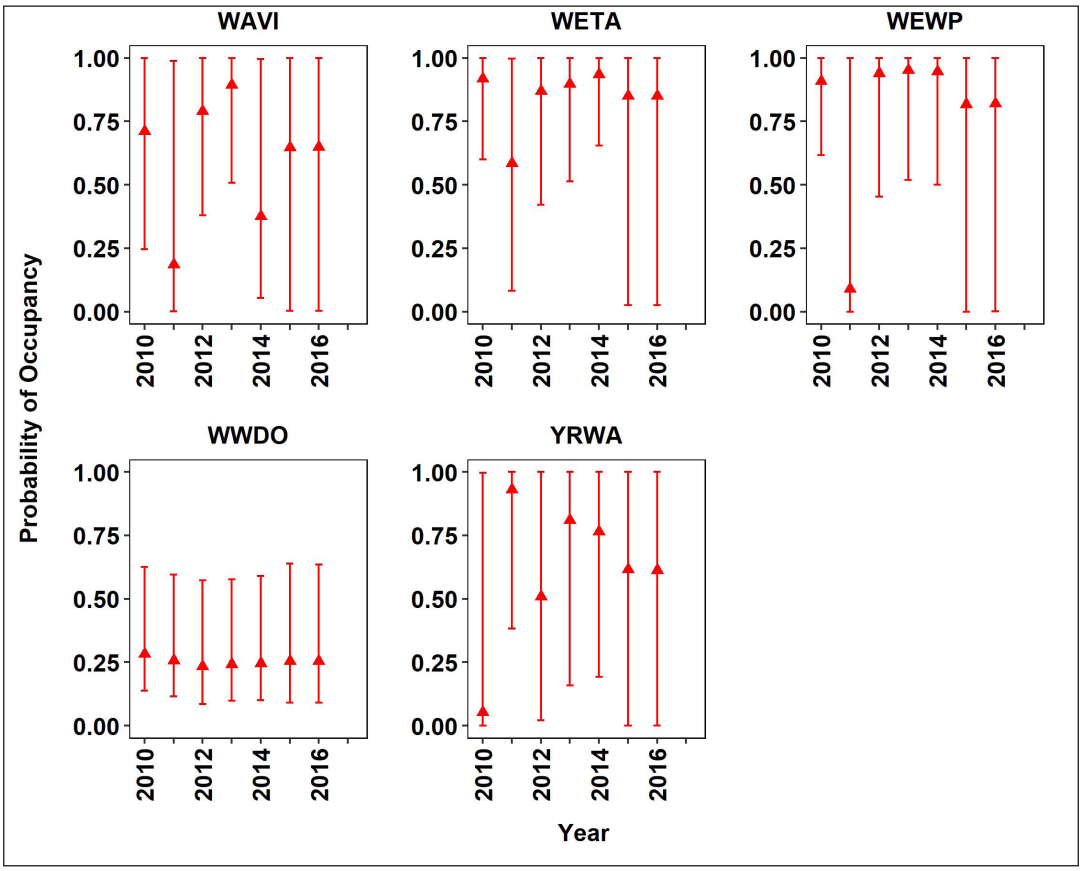


Figure D-39b. Estimated probability of occupancy, for more members of the woodland breeding habitat guild, by year for points (unconditional point occupancy) from Guadalupe Mountains NP riparian surveys. Because there was only one transect in this park-habitat, occupancy was estimated only at the point scale. Symbol = Bayesian posterior median, error bars = 95% credible interval. Species codes available in appendix table.

Riparian/wetland breeding habitat guild

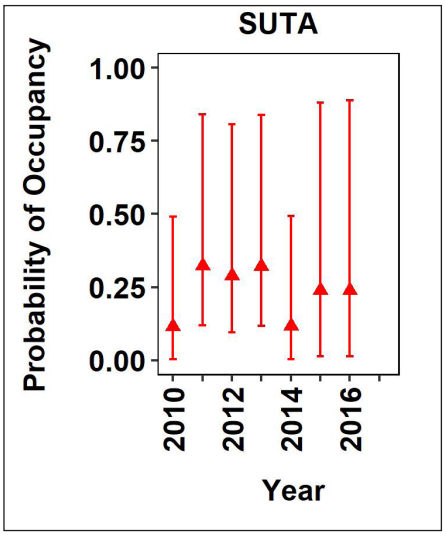


Figure D-40. Estimated probability of occupancy, for a member of the riparian/wetland breeding habitat guild, by year for points (unconditional point occupancy) from Guadalupe Mountains NP riparian surveys. Because there was only one transect in this park-habitat, occupancy was estimated only at the point scale. Symbol = Bayesian posterior median, error bars = 95% credible interval. SUTA = Summer Tanager.

D.10 White Sands NP Upland Habitat

Upland generalist breeding habitat guild

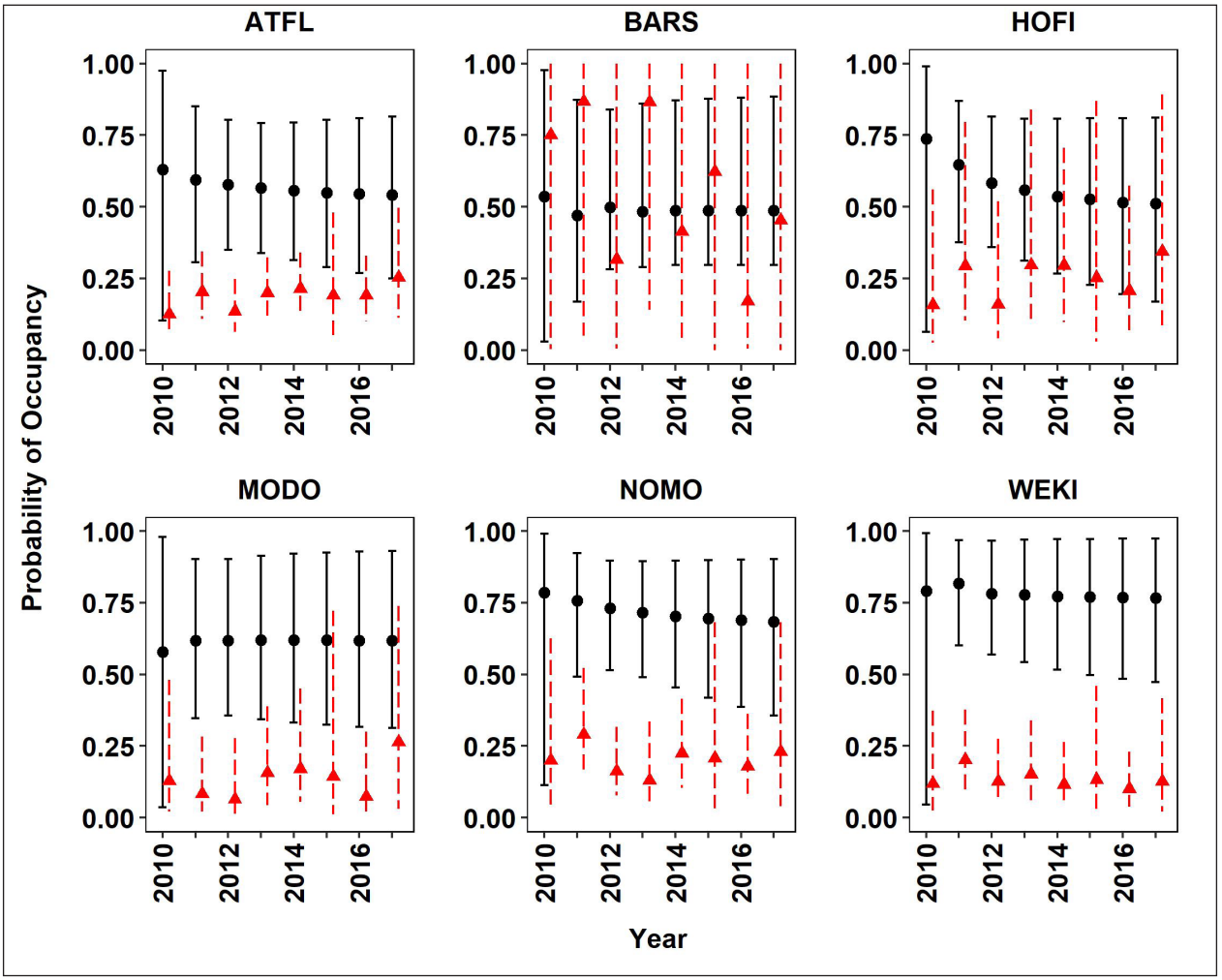


Figure D-41. Estimated probability of occupancy, for members of the upland generalist breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from White Sands NP upland surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. Species codes available in appendix table.

Grassland breeding habitat guild

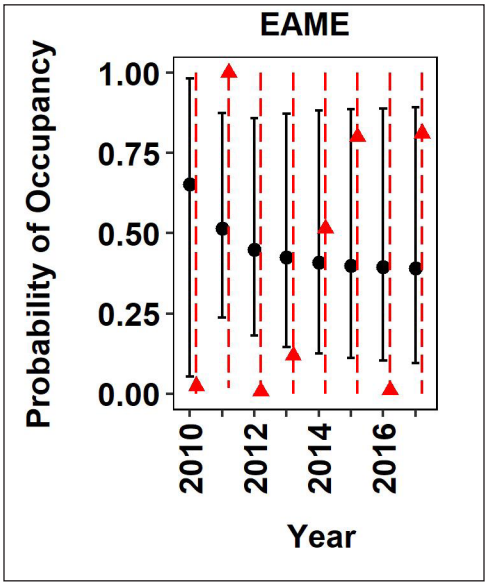


Figure D-42. Estimated probability of occupancy, for a member of the grassland breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from White Sands NP upland surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. EAME = Eastern Meadowlark.

Shrubland breeding habitat guild

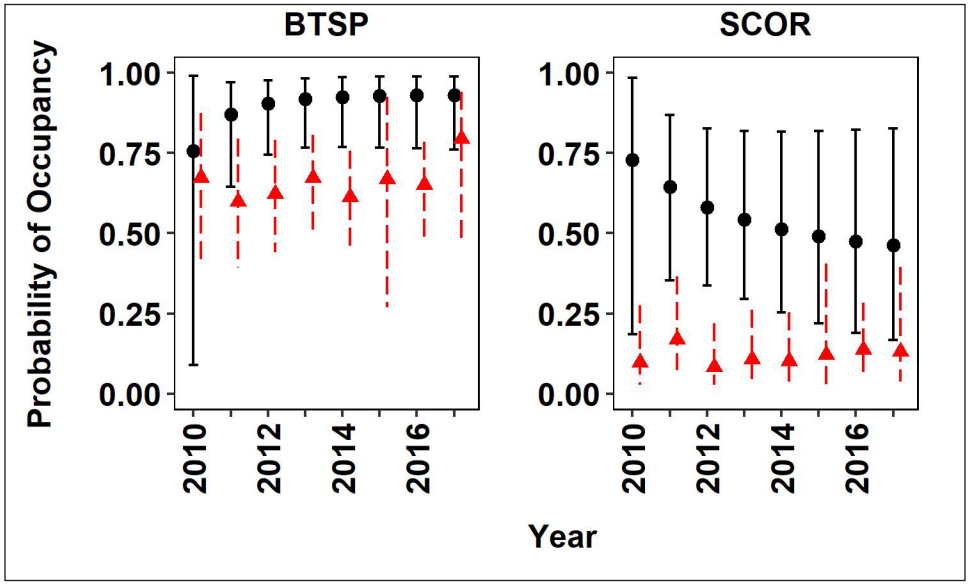


Figure D-43. Estimated probability of occupancy, for members of the shrubland breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from White Sands NP upland surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. BTSP = Black-throated Sparrow, SCOR = Scott's Oriole.

Woodland breeding habitat guild

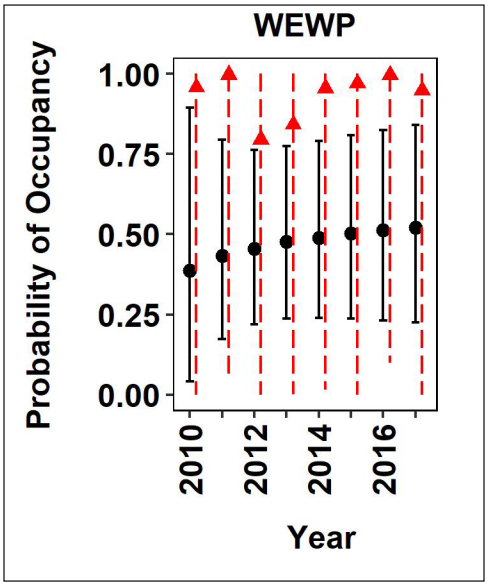


Figure D-44. Estimated probability of occupancy, for a member of the woodland breeding habitat guild, by year for transects (black/solid) and points within occupied transects (conditional point occupancy, red/dashed) from White Sands NP upland surveys. Symbol = Bayesian posterior median, error bars = 95% credible interval. WEWP = Western Wood-Pewee.

Table D-1. Common names for landbird species shown in Appendix D figures. The list is in alphabetical order according to common name (and only roughly by species code).

Species Code	Common Name
ATFL	Ash-throated Flycatcher
BARS	Barn Swallow
BEVI	Bell's Vireo
BEWR	Bewick's Wren
BLPH	Black Phoebe
BCHU	Black-chinned Hummingbird
BCSP	Black-chinned Sparrow
BCTI	Black-crested Titmouse
BHGR	Black-headed Grosbeak
BTGN	Black-tailed Gnatcatcher
BTSP	Black-throated Sparrow
BLGR	Blue Grosbeak
BGGN	Blue-gray Gnatcatcher
BTAH	Blue-tailed Hummingbird
BHCO	Brown-headed Cowbird
CACW	Cactus Wren
CANT	Canyon Towhee
CANW	Canyon Wren
CAKI	Cassin's Kingbird
CASP	Cassin's Sparrow
CHSP	Chipping Sparrow
CLSW	Cliff Swallow
COGD *	Common Ground Dove *
COYE	Common Yellowthroat
CRTH	Crissal Thrasher
CBTH	Curve-billed Thrasher
EAME	Eastern Meadowlark
EUCD	Eurasian collared-dove
GRRO	Greater Roadrunner
GTGR	Great-tailed Grackle
GTTO	Green-tailed Towhee
HOFI	House Finch
HOWR	House Wren
INBU	Indigo Bunting
LBWO	Ladder-backed Woodpecker
LASP	Lark Sparrow
LEGO	Lesser Goldfinch
LOSH	Loggerhead Shrike
LUWA	Lucy’s Warbler
MODO	Mourning Dove
NOCA	Northern Cardinal
NOMO	Northern Mockingbird
NRWS	Northern Rough-winged Swallow
ORIOR	Orchard Oriole
PABU	Painted Bunting
PHAI	Phainopepla
PLVI	Plumbeous Vireo
PYRR	Pyrrhuloxia
RWBL	Red-winged Blackbird
ROWR	Rock Wren
RCSP	Rufous-crowned Sparrow
SAPH	Say's Phoebe
SCQU	Scaled Quail
SCOR	Scott's Oriole
SPTO	Spotted Towhee
SUTA	Summer Tanager
VERD	Verdin
VEFL	Vermilion Flycatcher
VGSW	Violet-green Swallow
WAVI	Warbling Vireo
WEKI	Western Kingbird
WETA	Western Tanager
WEWP	Western Wood-Pewee
WTSW	White-throated Swift
WWDO	White-winged Dove
WITU	Wild Turkey
YBCH	Yellow-breasted Chat
YRWA	Yellow-rumped Warbler

* Code was changed to CGDO, and common name spelling was changed to Common Ground Dove, according to the 2019 60th AOU supplement.

Appendix E. Annual Density Estimates for Landbird Species by Park-Habitat and Breeding Habitat Guild.

Figures E-1 to E-30 show annual density estimates for species according to park-habitat and breeding habitat guild. Density estimates presented in the main report are by species and park-habitat, and the estimates were averaged over years. Details on density analytical methods are provided in Section 2.5.3 of the main report. Note that two species reported here either did not meet our formal criteria for inclusion in Chapter 3 (Scaled Quail) or were omitted from Chapter 3 because only one set of extremely low density estimates was obtained (Chihuahuan Raven).

E.1 Amistad National Recreation Area (NRA) Upland Habitat

Upland generalist breeding habitat guild

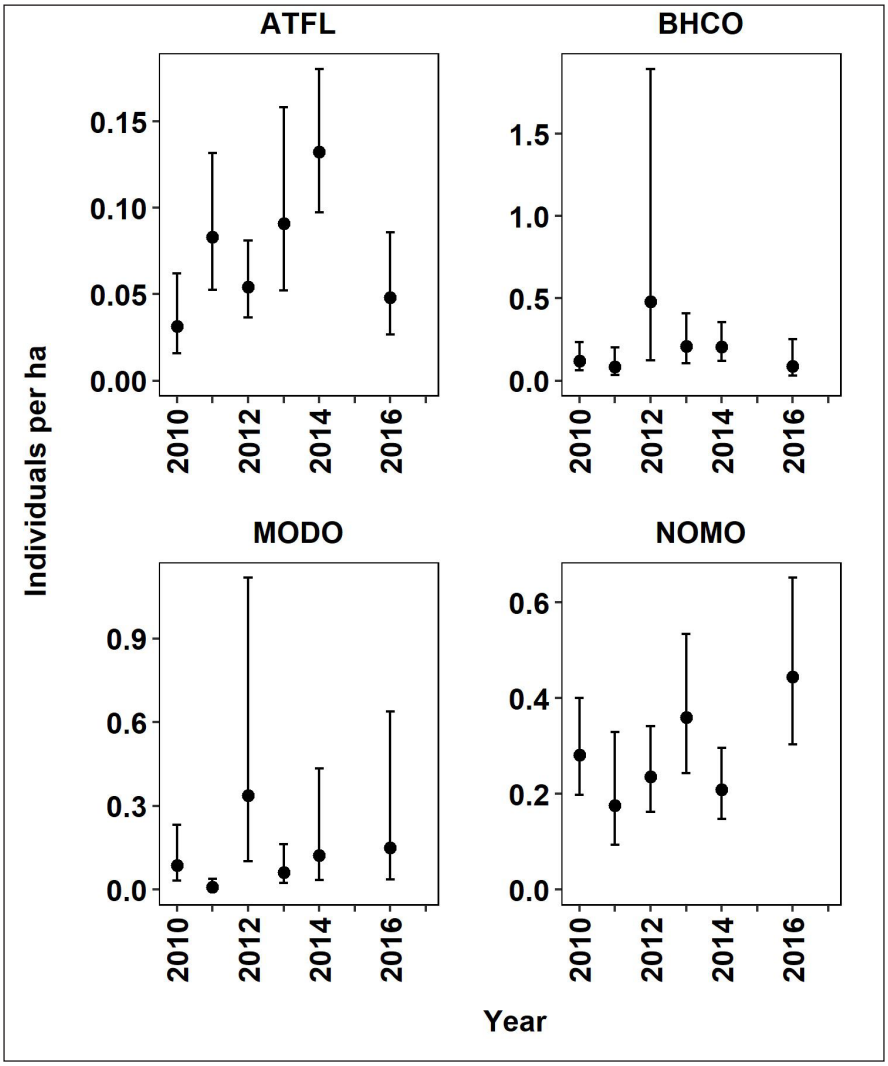


Figure E-1. Yearly estimates of density for ATFL (Ash-throated Flycatcher), BHCO (Brown-headed Cowbird), MODO (Mourning Dove), and NOMO (Northern Mockingbird), members of the upland generalist breeding habitat guild, in Amistad NRA upland habitat surveyed. Error bars are 95% confidence intervals.

Grassland breeding habitat guild

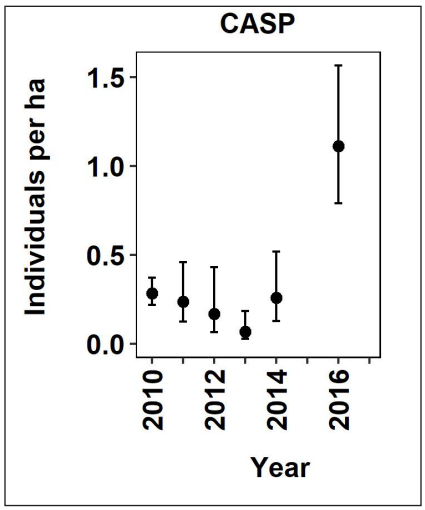


Figure E-2. Yearly estimates of density for CASP (Cassin's Sparrow), a member of the grassland breeding habitat guild, in Amistad NRA upland habitat surveyed. Error bars are 95% confidence intervals.

Shrubland breeding habitat guild

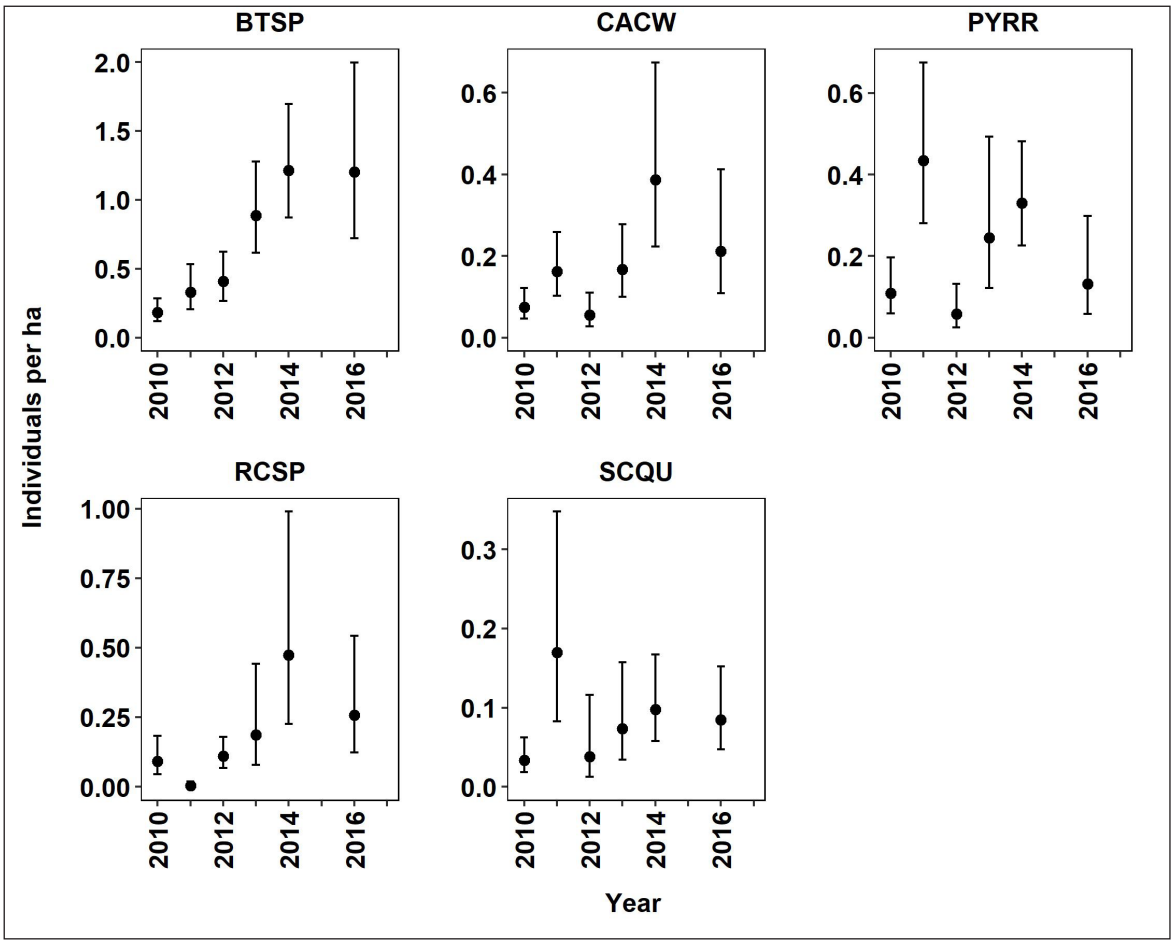


Figure E-3. Yearly estimates of density for BTSP (Black-throated Sparrow), CACW (Cactus Wren), PYRR (Pyrrhuloxia), RCSP (Rufous-crowned Sparrow), and SCQU (Scaled Quail), members of the shrubland breeding habitat guild, in Amistad NRA upland habitat surveyed. Error bars are 95% confidence intervals.

Woodland breeding habitat guild

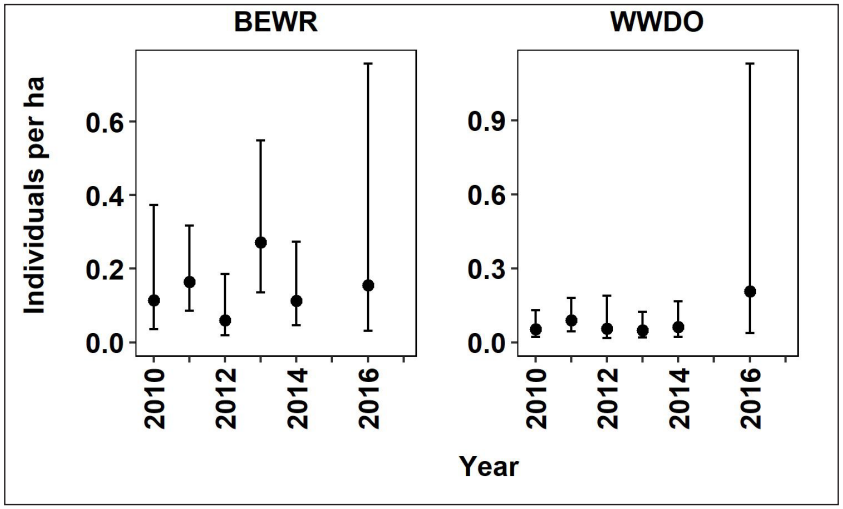


Figure E-4. Yearly estimates of density for BEWR (Bewick's Wren) and WWDO (White-winged Dove), members of the woodland breeding habitat guild, in Amistad NRA upland habitat surveyed. Error bars are 95% confidence intervals.

Riparian/wetland breeding habitat guild

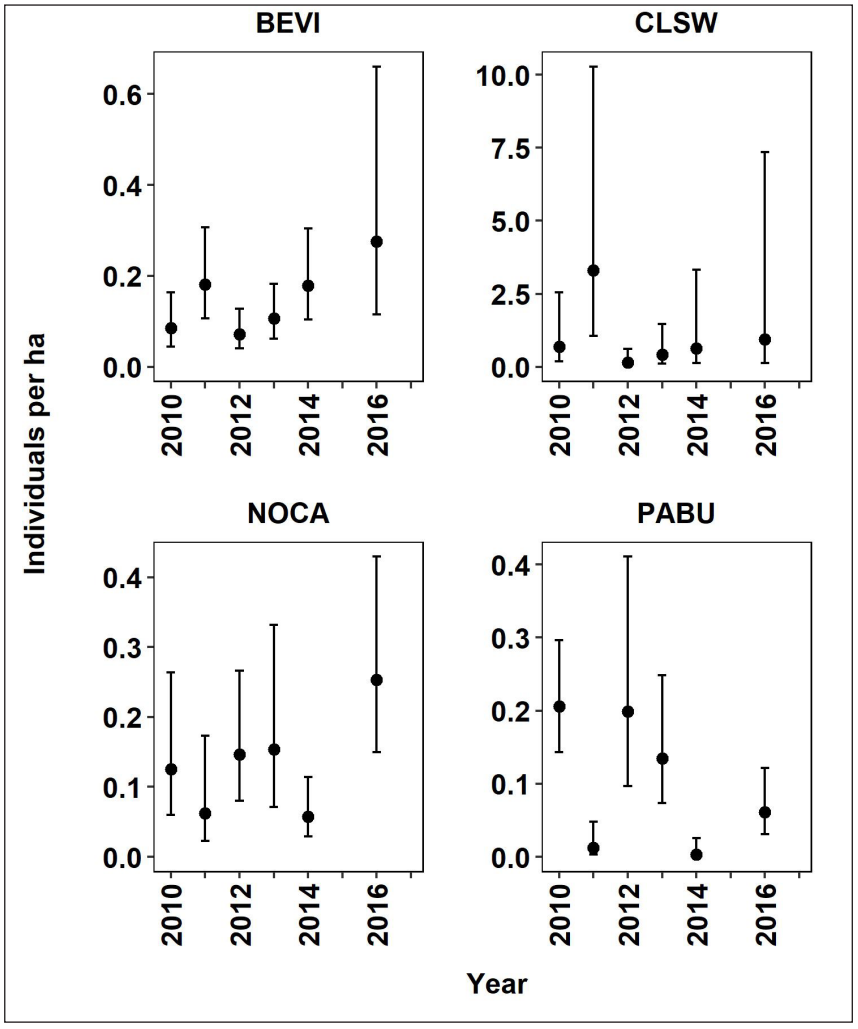


Figure E-5. Yearly estimates of density for BEVI (Bell's Vireo), CLSW (Cliff Swallow), NOCA (Northern Cardinal), and PABU (Painted Bunting), members of the riparian/wetland breeding habitat guild, in Amistad NRA upland habitat surveyed. Error bars are 95% confidence intervals.

E.2 Amistad NRA Riparian Habitat

Upland generalist br. habitat guild

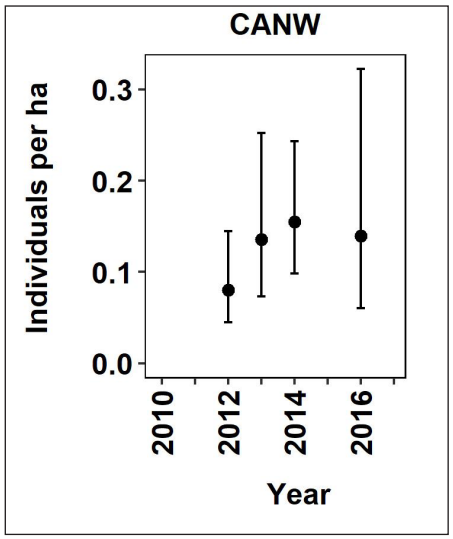


Figure E-6. Yearly estimates of density for CANW (Canyon Wren), a member of the upland generalist breeding habitat guild, in Amistad NRA riparian habitat surveyed. Error bars are 95% confidence intervals.

Woodland breeding habitat guild

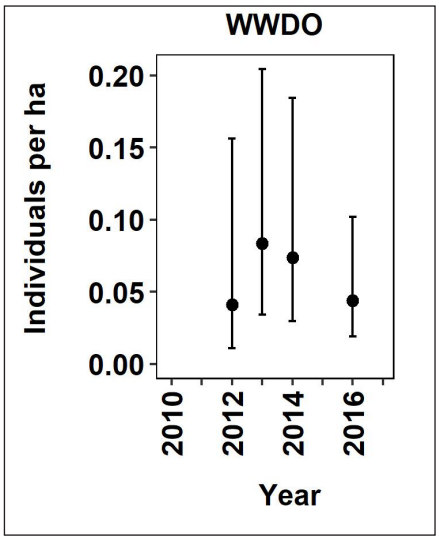


Figure E-7. Yearly estimates of density for WWDO (White-winged Dove), a member of the woodland breeding habitat guild, in Amistad NRA riparian habitat surveyed. Error bars are 95% confidence intervals.

Riparian/wetland breeding habitat guild

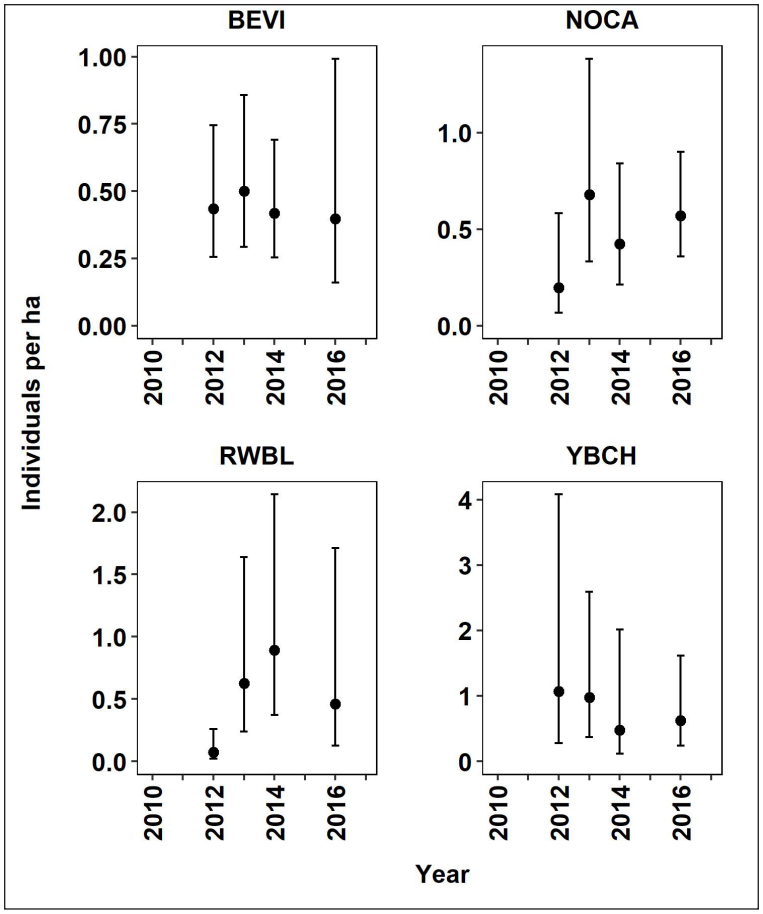


Figure E-8. Yearly estimates of density for BEVI (Bell's Vireo), NOCA (Northern Cardinal), RWBL (Red-winged Blackbird), YBCH (Yellow-breasted Chat), members of the riparian/wetland breeding habitat guild, in Amistad NRA riparian habitat surveyed. Error bars are 95% confidence intervals.

E.3 Big Bend National Park (NP) Upland Habitat

Upland generalist breeding habitat guild

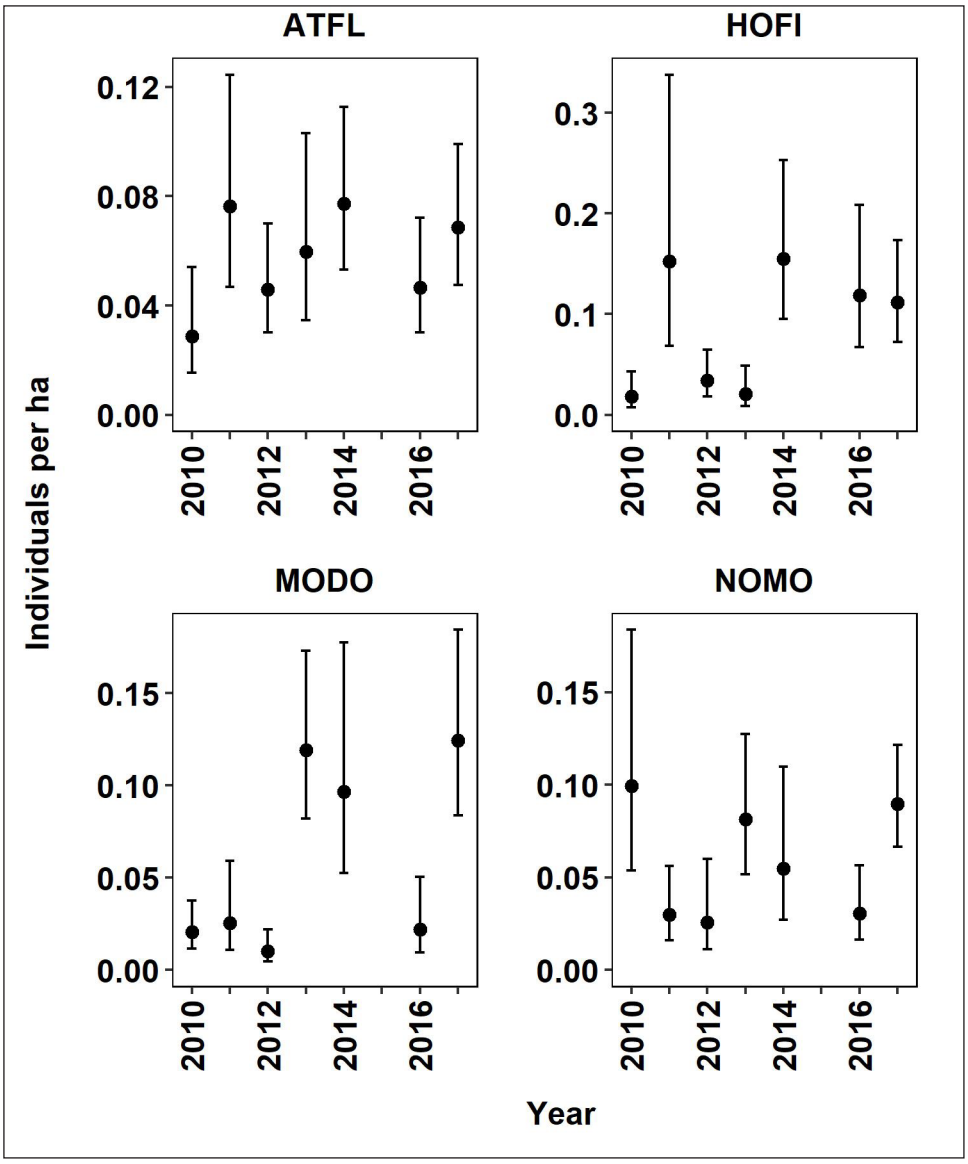


Figure E-9. Yearly estimates of density for ATFL (Ash-throated Flycatcher), HOFI (House Finch), MODO (Mourning Dove), and NOMO (Northern Mockingbird), members of the upland generalist breeding habitat guild, in Big Bend NP upland habitat surveyed. Error bars are 95% confidence intervals.

Grassland breeding habitat guild

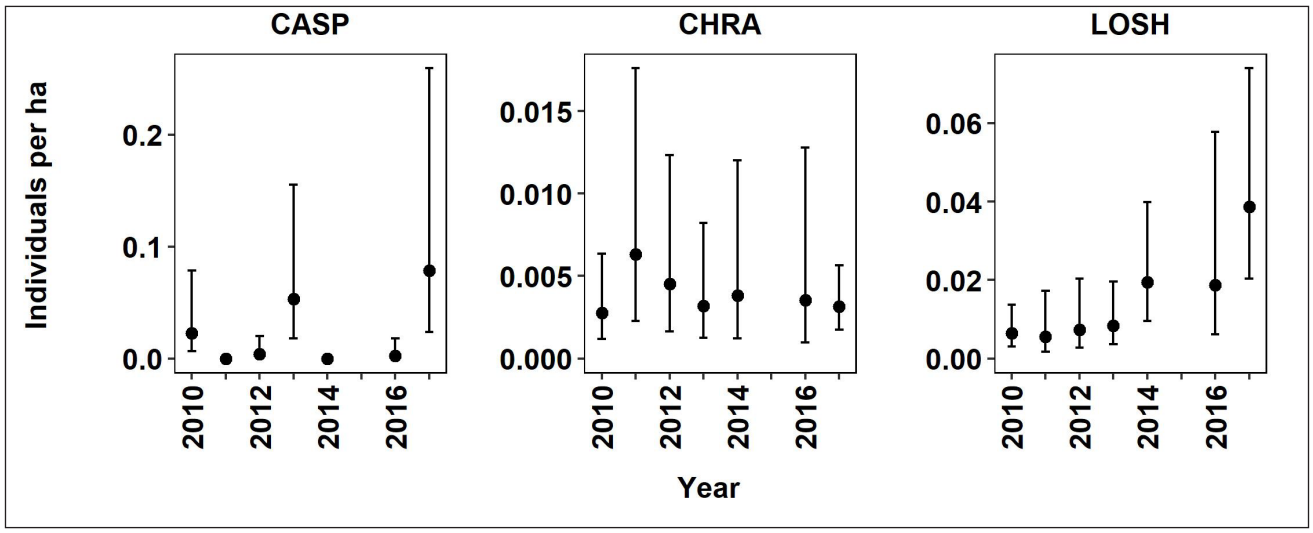


Figure E-10. Yearly estimates of density for CASP (Cassin's Sparrow), CHRA (Chihuahuan Raven), and LOSH (Loggerhead Shrike), members of the grassland breeding habitat guild, in Big Bend NP upland habitat surveyed. Error bars are 95% confidence intervals.

Shrubland breeding habitat guild

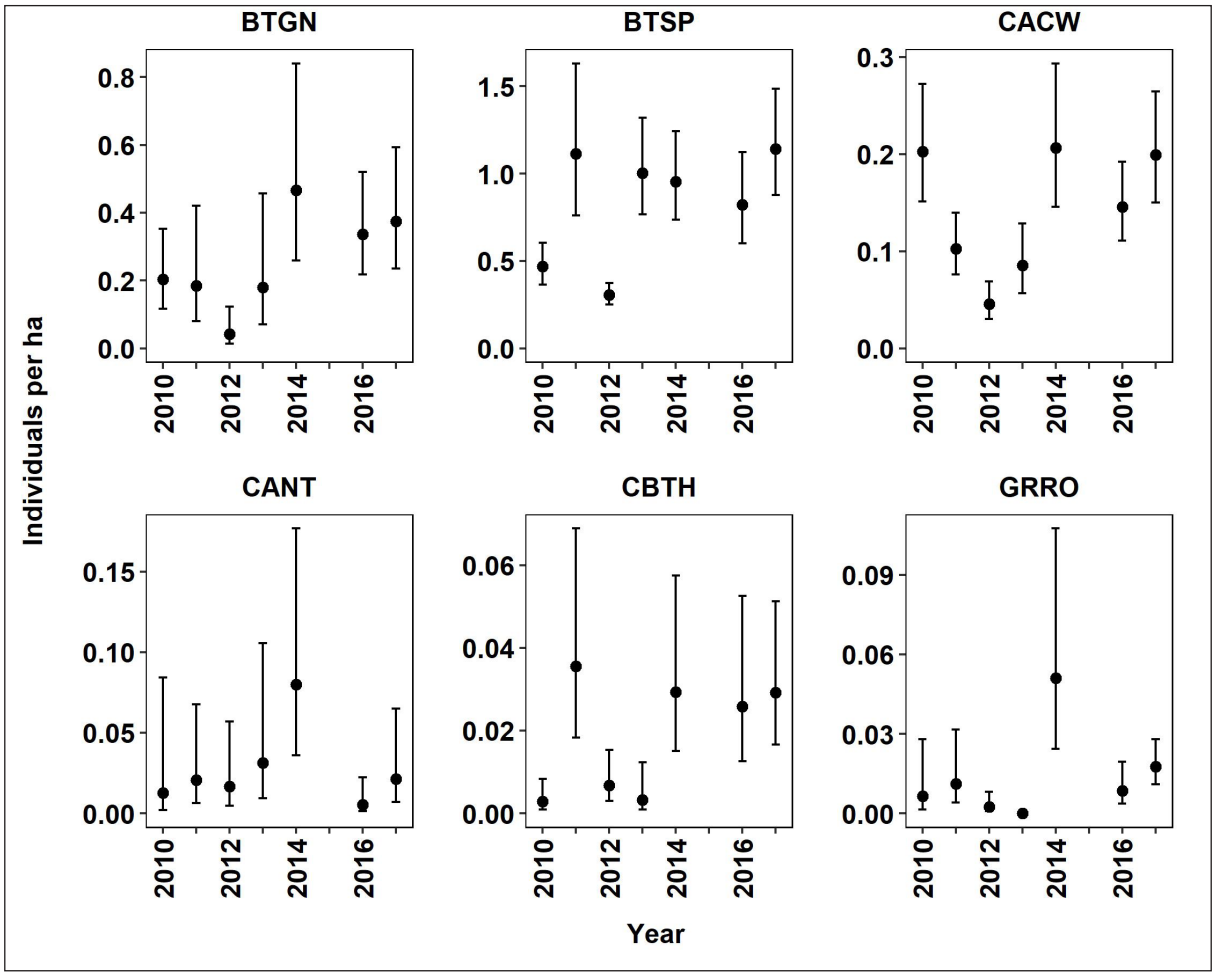


Figure E-11a. Yearly estimates of density for BTGN (Black-tailed Gnatcatcher), BTSP (Black-throated Sparrow), CACW (Cactus Wren), CANT (Canyon Towhee), CBTH (Curve-billed Thrasher), and GRRO (Greater Roadrunner), members of the shrubland breeding habitat guild, in Big Bend NP upland habitat surveyed. Error bars are 95% confidence intervals.

Shrubland breeding habitat guild...continued

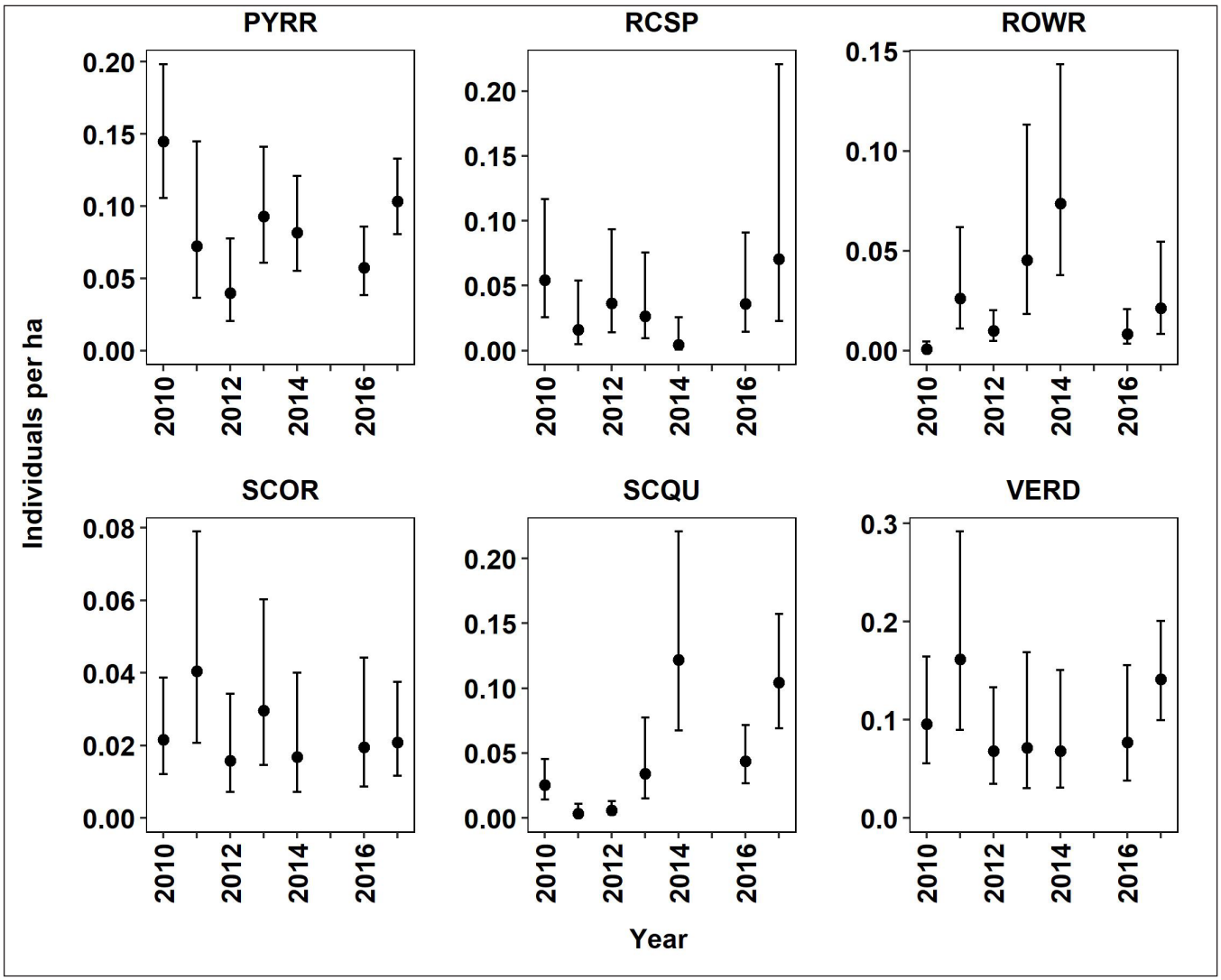


Figure E-11b. Yearly estimates of density for PYRR (Pyrrhuloxia), RCSP (Rufous-crowned Sparrow), ROWR (Rock Wren), SCOR (Scott's Oriole), SCQU (Scaled Quail), and VERD (Verdin), members of the shrubland breeding habitat guild, in Big Bend NP upland habitat surveyed. Error bars are 95% confidence intervals.

Woodland breeding habitat guild

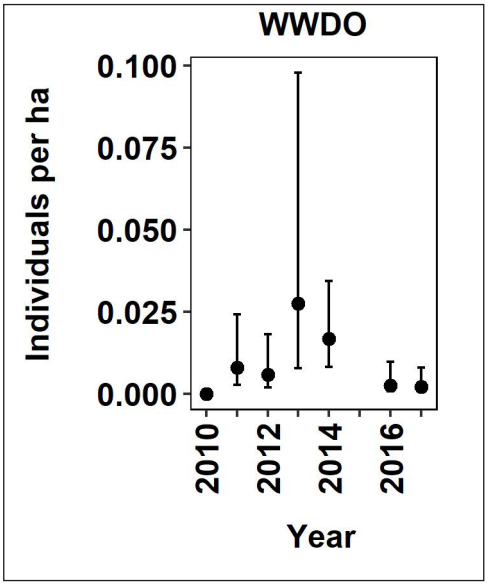


Figure E-12. Yearly estimates of density for WWDO (White-winged Dove), a member of the woodland breeding habitat guild, in Big Bend NP upland habitat surveyed. Error bars are 95% confidence intervals.

Riparian/wetland breeding habitat guild

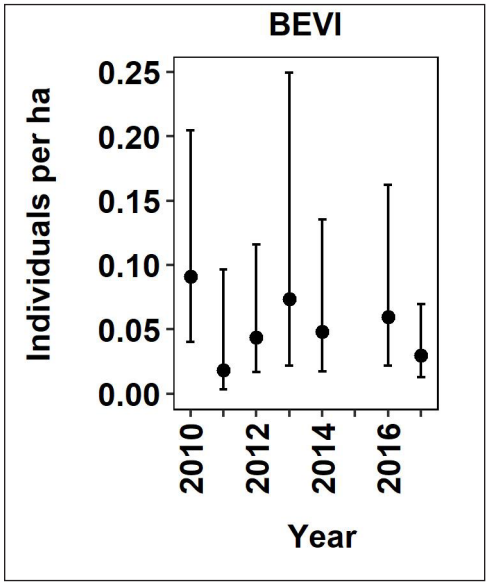


Figure E-13. Yearly estimates of density for BEVI (Bell's Vireo), a member of the riparian/ wetland breeding habitat guild, in Big Bend NP upland habitat surveyed. Error bars are 95% confidence intervals.

E.4 Big Bend NP Riparian Habitat

Upland generalist breeding habitat guild

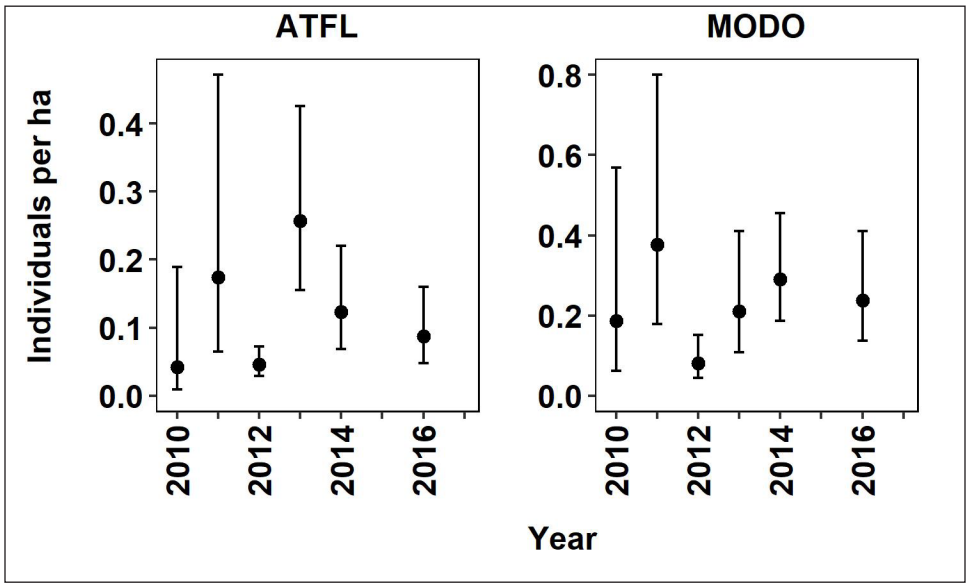


Figure E-14. Yearly estimates of density for ATFL (Ash-throated Flycatcher) and MODO (Mourning Dove), members of the upland generalist breeding habitat guild, in Big Bend NP riparian habitat surveyed. Error bars are 95% confidence intervals.

Woodland breeding habitat guild

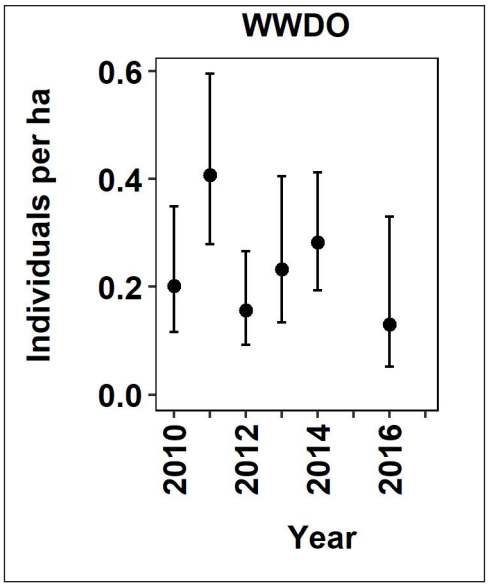


Figure E-15. Yearly estimates of density for WWDO (White-winged Dove), a member of the woodland breeding habitat guild, in Big Bend NP riparian habitat surveyed. Error bars are 95% confidence intervals.

Riparian/wetland breeding habitat guild

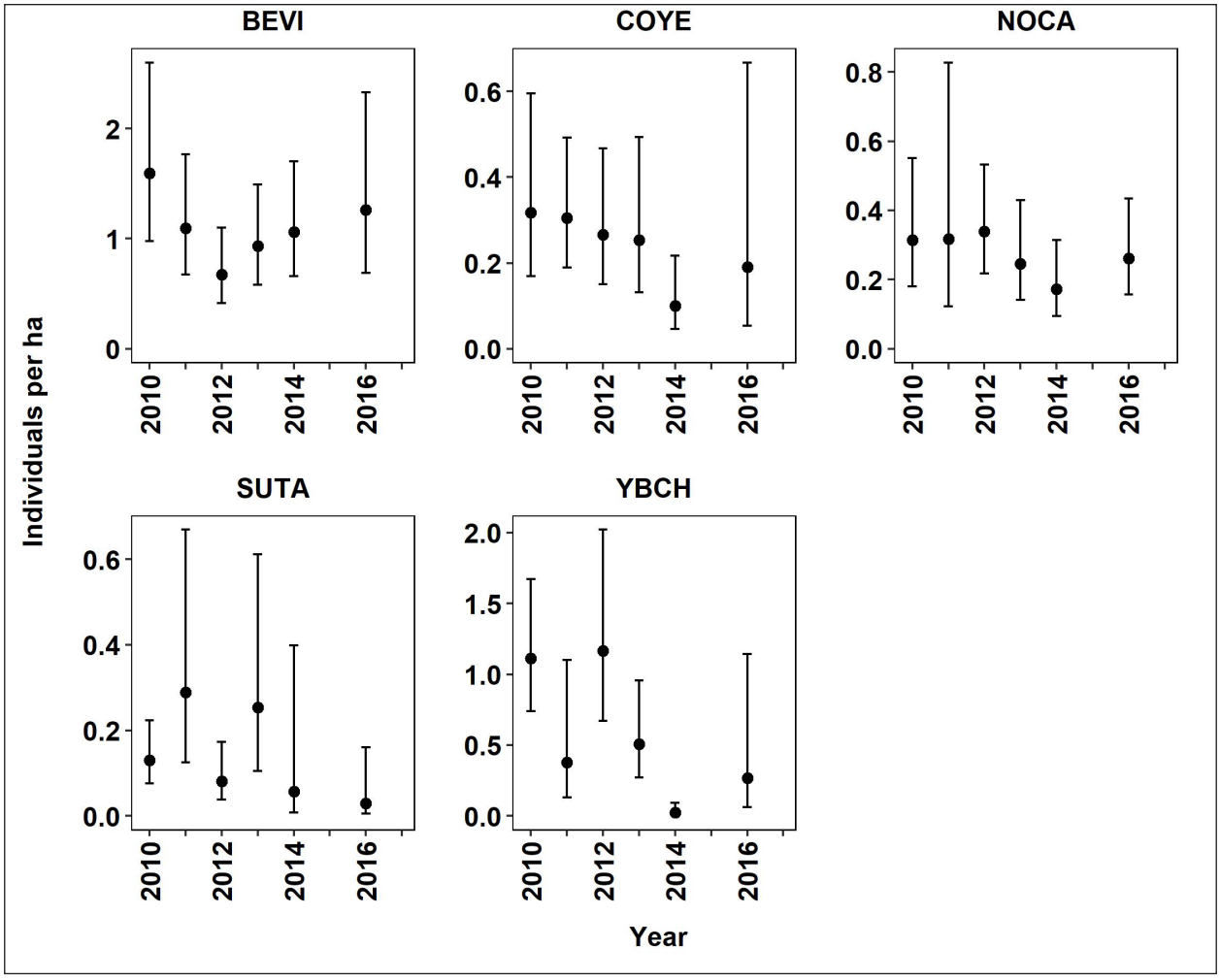


Figure E-16. Yearly estimates of density for BEVI (Bell's Vireo), COYE (Common Yellowthroat), NOCA (Northern Cardinal), SUTA (Summer Tanager), and YBCH (Yellow-breasted Chat), members of the riparian/wetland breeding habitat guild, in Big Bend NP riparian habitat surveyed. Error bars are 95% confidence intervals.

E.5 Carlsbad Caverns NP Upland Habitat

Upland generalist breeding habitat guild

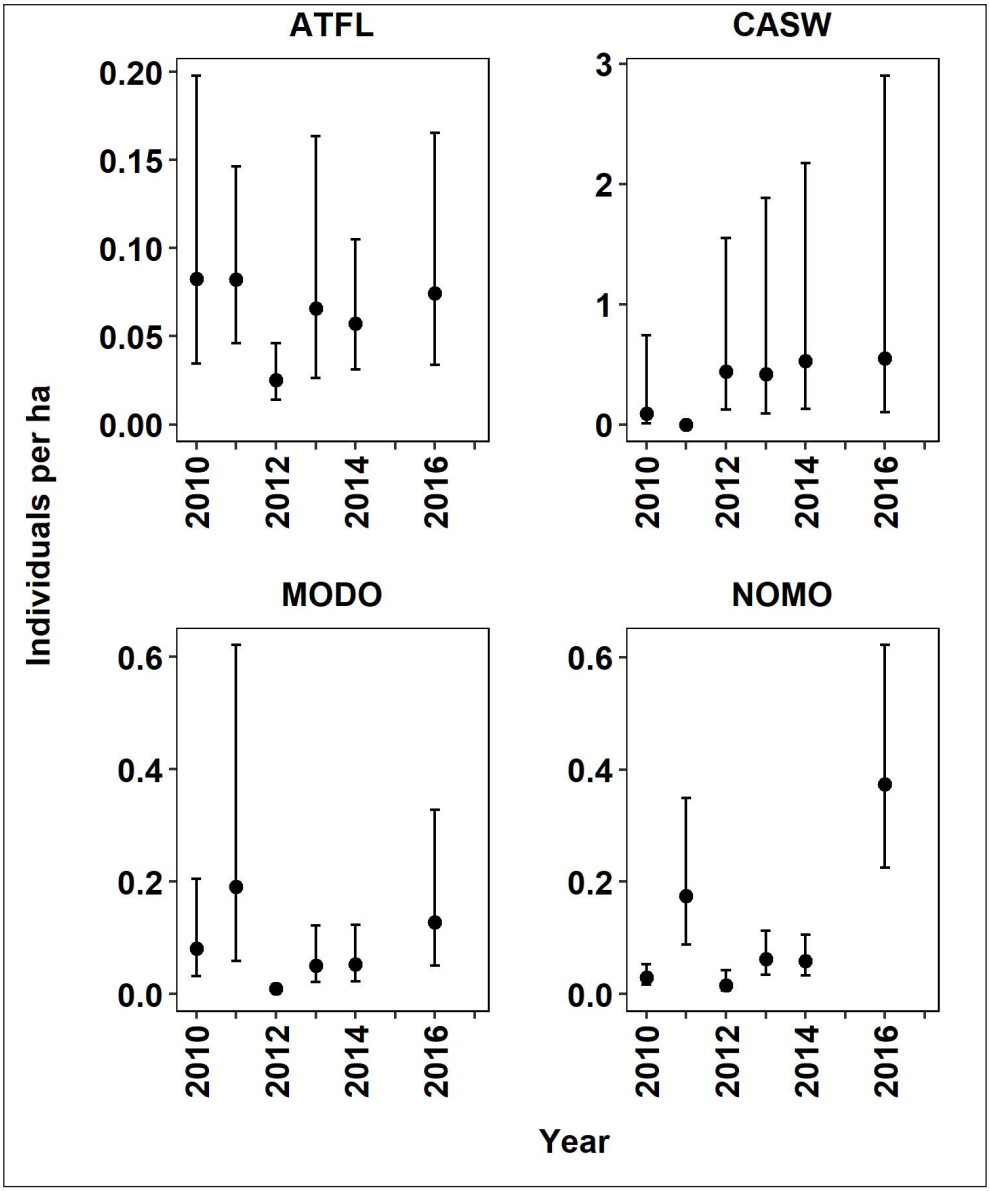


Figure E-17. Yearly estimates of density for ATFL (Ash-throated Flycatcher), CASW (Cave Swallow), MODO (Mourning Dove), and NOMO (Northern Mockingbird), members of the upland generalist breeding habitat guild, in Carlsbad Caverns NP upland habitat surveyed. Error bars are 95% confidence intervals.

Grassland breeding habitat guild

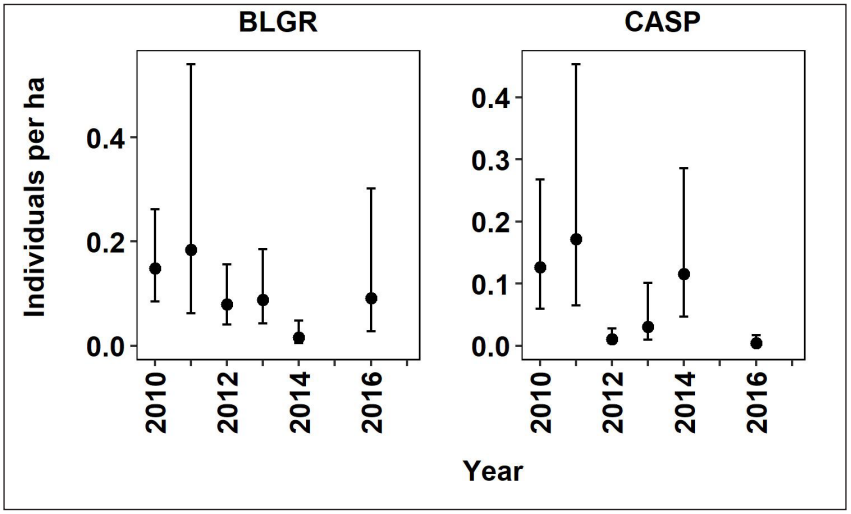


Figure E-18. Yearly estimates of density for BLGR (Blue Grosbeak) and CASP (Cassin's Sparrow), members of the grassland breeding habitat guild, in Carlsbad Caverns NP upland habitat surveyed. Error bars are 95% confidence intervals.

Shrubland breeding habitat guild

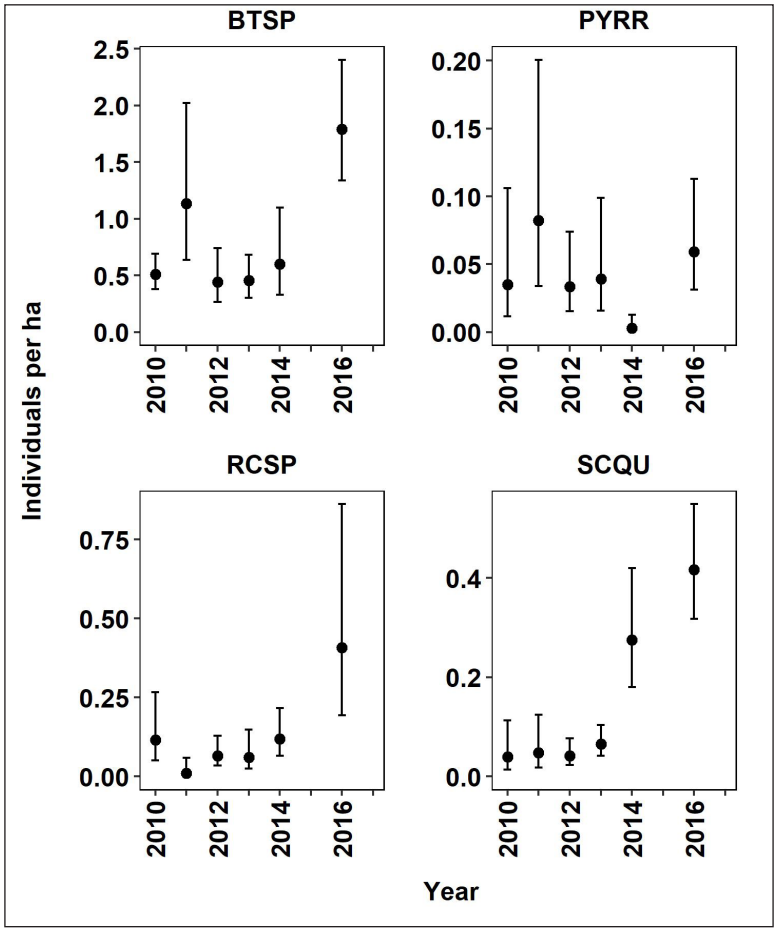


Figure E-19. Yearly estimates of density for BTSP (Black-throated Sparrow), PYRR (Pyrrhuloxia), RCSP (Rufous-crowned Sparrow), and SCQU (Scaled Quail), members of the shrubland breeding habitat guild, in Carlsbad Caverns NP upland habitat surveyed. Error bars are 95% confidence intervals.

E.6 Carlsbad Caverns NP Riparian Habitat

Woodland breeding habitat guild

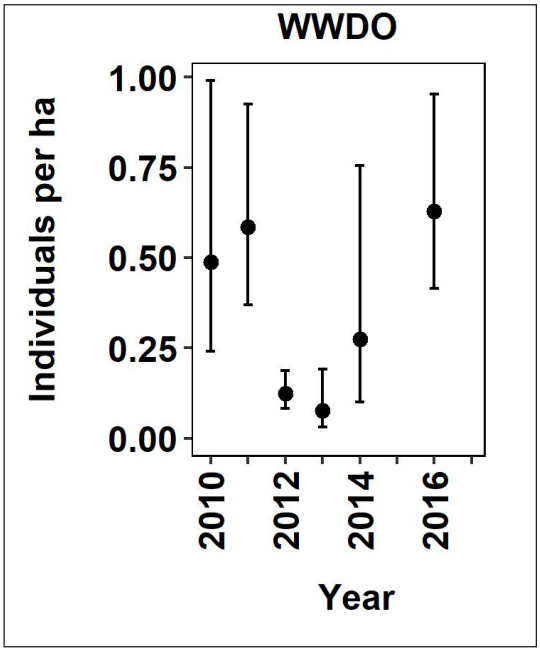


Figure E-20. Yearly estimates of density for WWDO (White-winged Dove), a member of the woodland breeding habitat guild, in Carlsbad Caverns NP riparian habitat surveyed. Error bars are 95% confidence intervals.

Riparian/wetland breeding habitat guild

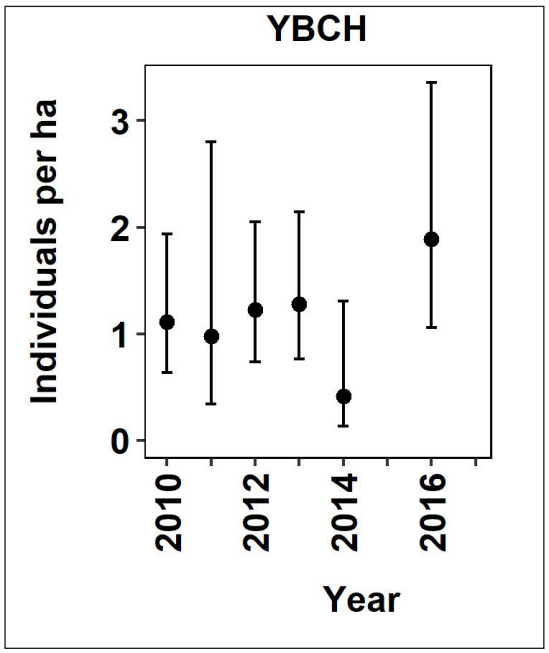


Figure E-21. Yearly estimates of density for YBCH (Yellow-breasted Chat), a member of the riparian/ wetland breeding habitat guild, in Carlsbad Caverns NP riparian habitat surveyed. Error bars are 95% confidence intervals.

E.7 Fort Davis National Historic Site (NHS) Upland Habitat

Upland generalist breeding habitat guild

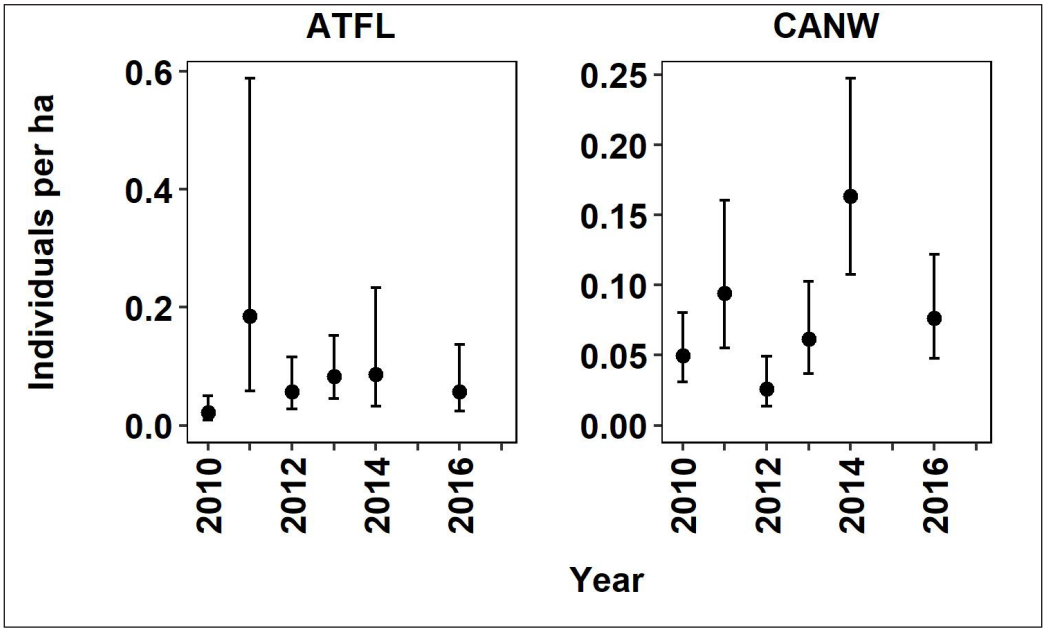


Figure E-22. Yearly estimates of density for ATFL (Ash-throated Flycatcher) and CANW (Canyon Wren), members of the upland generalist breeding habitat guild, in Fort Davis NHS upland habitat surveyed. Error bars are 95% confidence intervals.

Shrubland breeding habitat guild

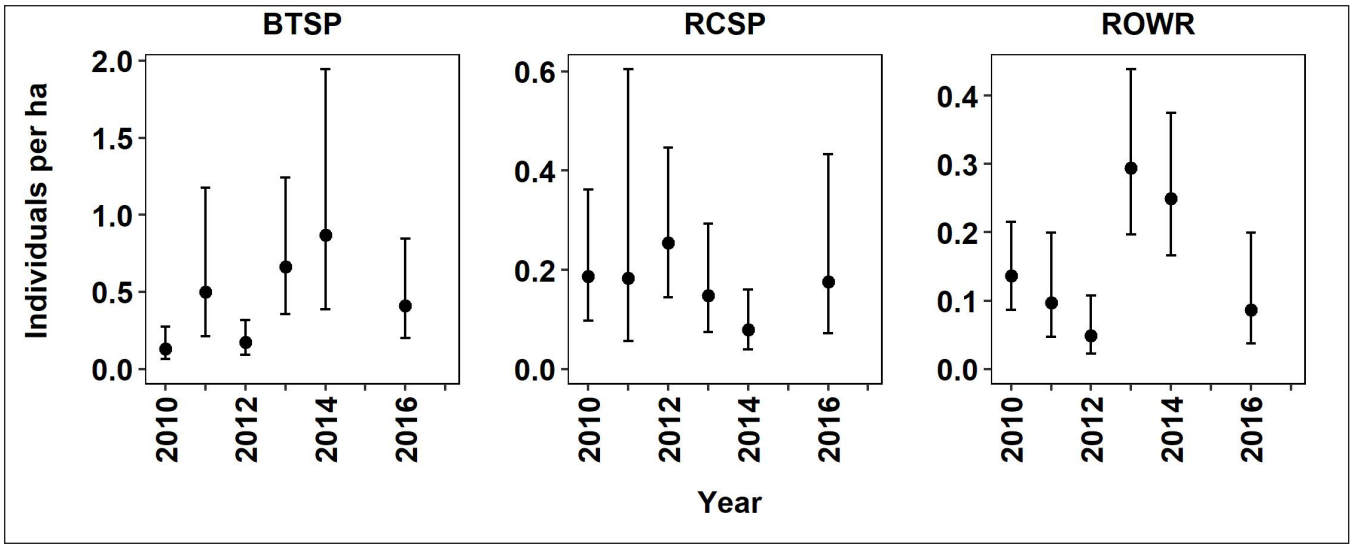


Figure E-23. Yearly estimates of density for BTSP (Black-throated Sparrow), RCSP (Rufous-crowned Sparrow), and ROWR (Rock Wren), members of the shrubland breeding habitat guild, in Fort Davis NHS upland habitat surveyed. Error bars are 95% confidence intervals.

Woodland breeding habitat guild

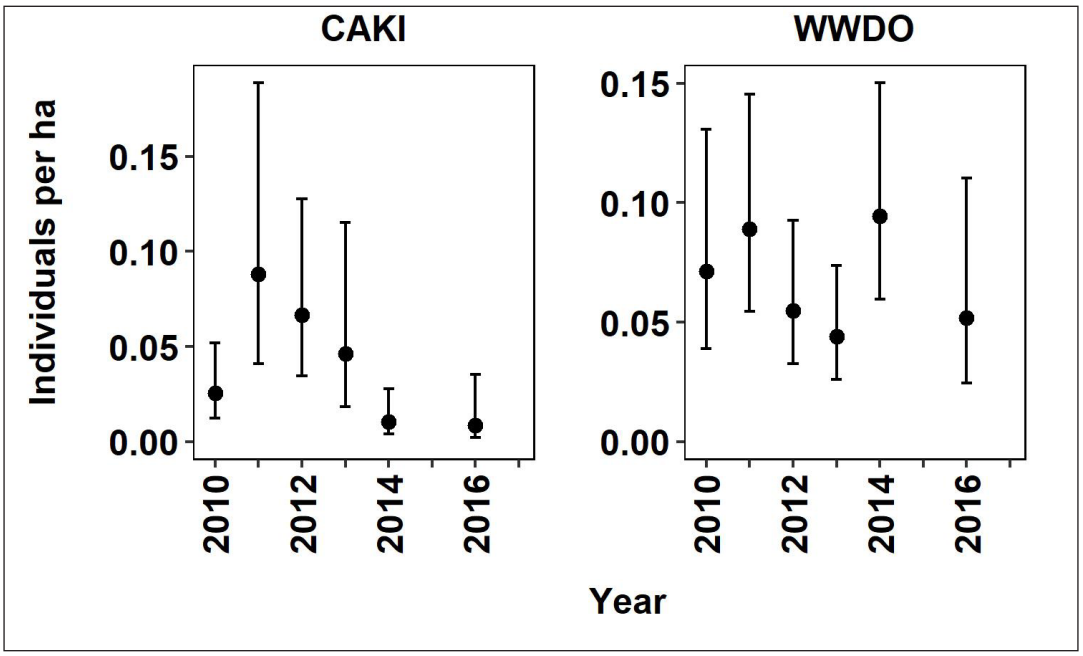


Figure E-24. Yearly estimates of density for CAKI (Cassin's Kingbird) and WWDO (White-winged Dove), members of the woodland breeding habitat guild, in Fort Davis NHS upland habitat surveyed. Error bars are 95% confidence intervals.

E.8 Guadalupe Mountains NP Upland Habitat

Upland generalist breeding habitat guild

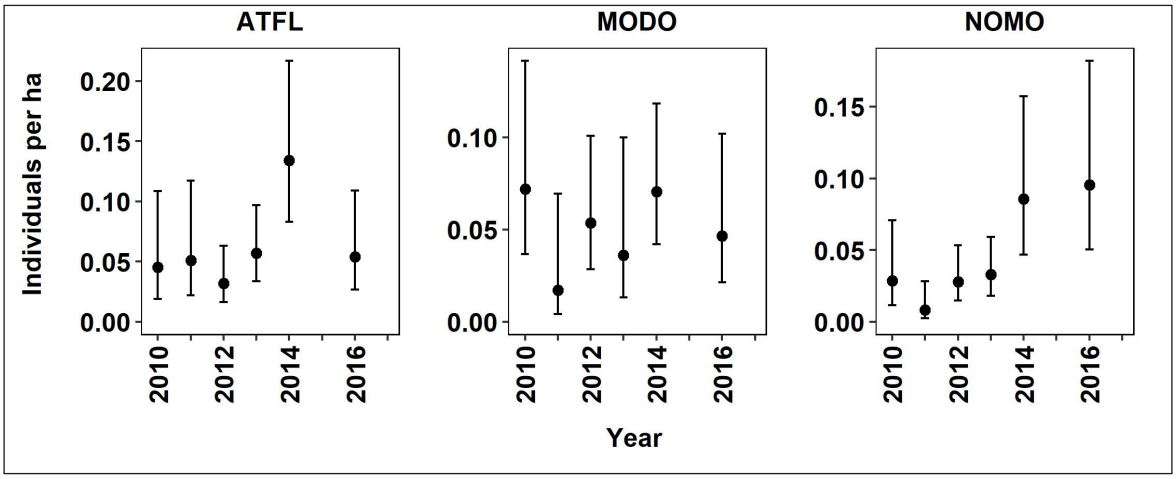


Figure E-25. Yearly estimates of density for ATFL (Ash-throated Flycatcher), MODO (Mourning Dove), and NOMO (Northern Mockingbird), members of the upland generalist breeding habitat guild, in Guadalupe Mountains NP upland habitat surveyed. Error bars are 95% confidence intervals.

Shrubland breeding habitat guild

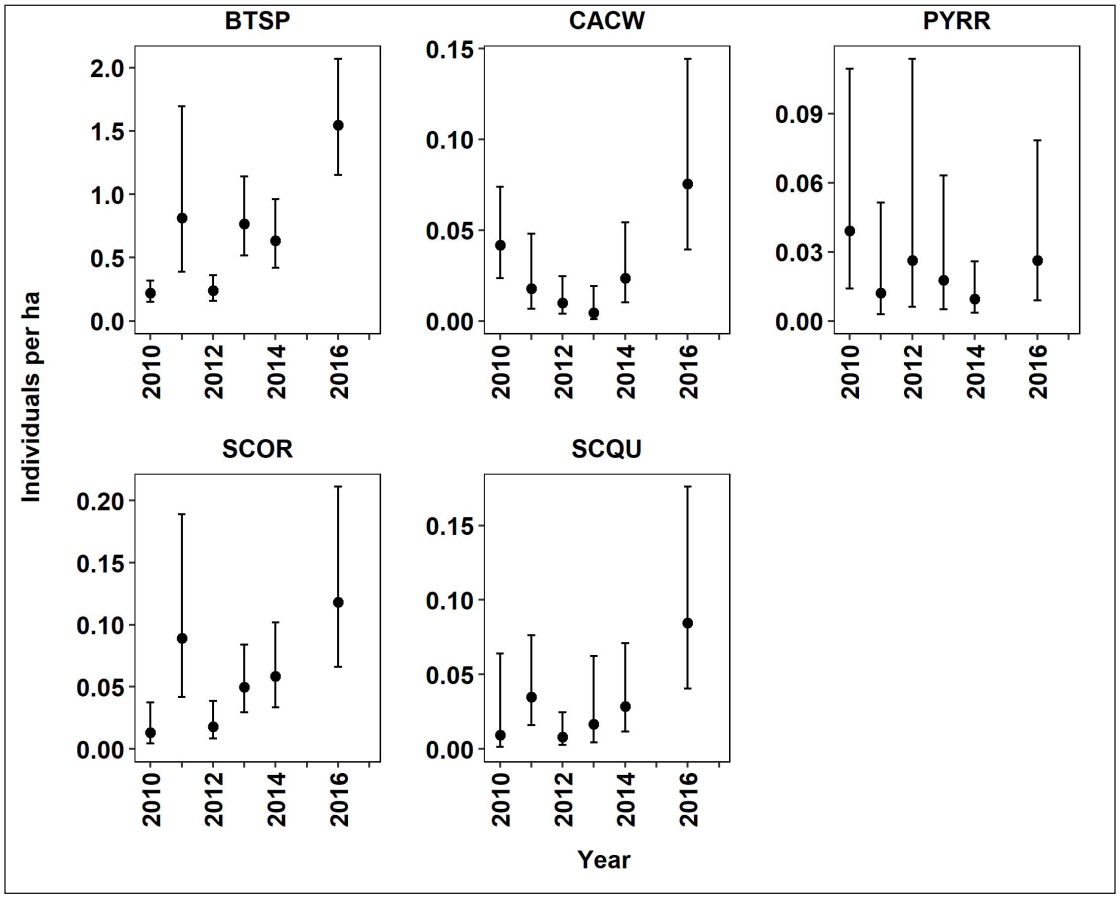


Figure E-26. Yearly estimates of density for BTSP (Black-throated Sparrow), CACW (Cactus Wren), PYRR (Pyrrhuloxia), SCOR (Scott's Oriole), and SCQU (Scaled Quail), members of the shrubland breeding habitat guild, in Guadalupe Mountains NP upland habitat surveyed. Error bars are 95% confidence intervals.

E.9 Guadalupe Mountains NP Riparian Habitat

Woodland breeding habitat guild

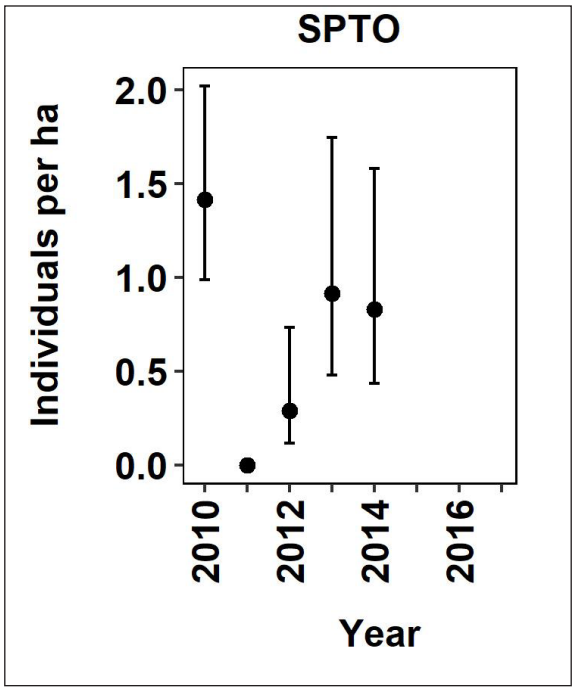


Figure E-27. Yearly estimates of density for SPTO (Spotted Towhee), a member of the woodland breeding habitat guild, in Guadalupe Mountains NP riparian habitat surveyed. Error bars are 95% confidence intervals.

E.10 White Sands NP Upland Habitat

Upland generalist breeding habitat guild

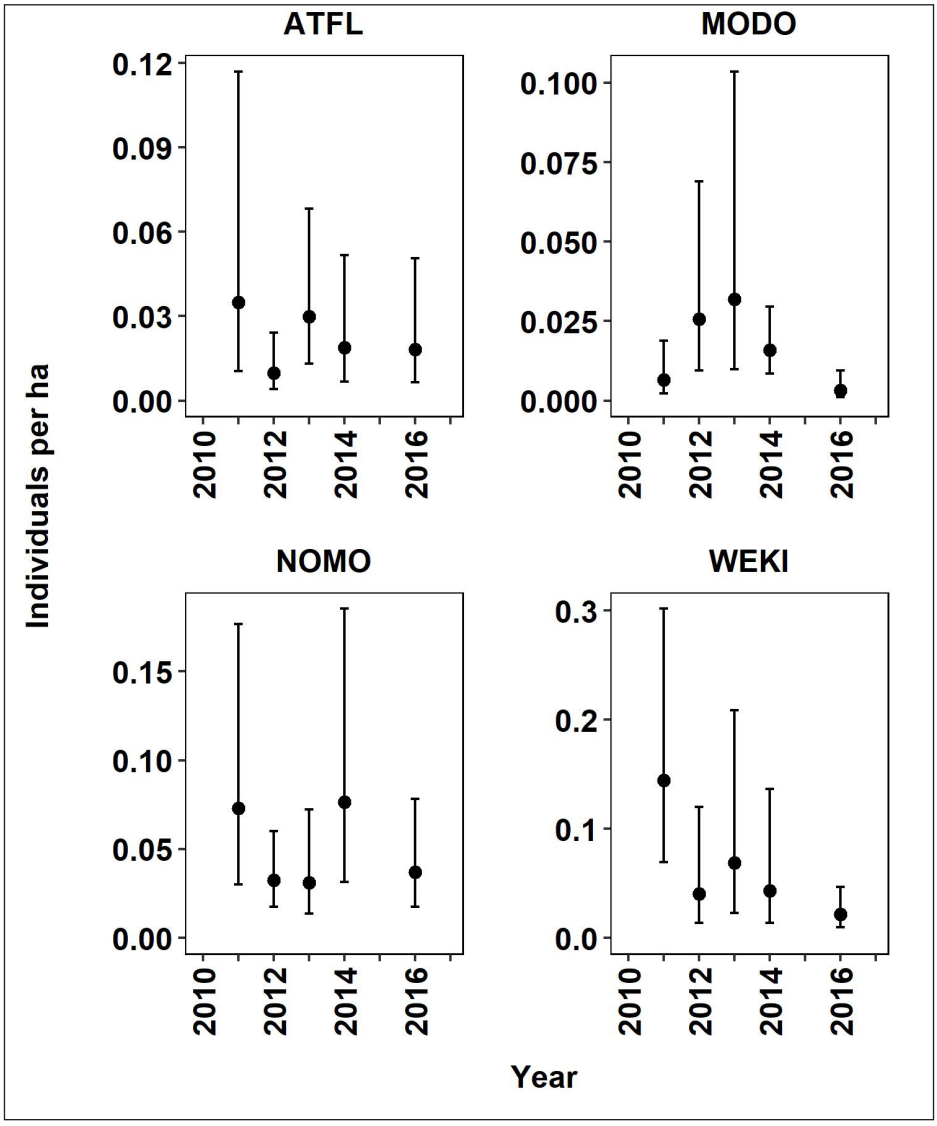


Figure E-28. Yearly estimates of density for ATFL (Ash-throated Flycatcher), MODO (Mourning Dove), NOMO (Northern Mockingbird), and WEKI (Western Kingbird), members of the upland generalist breeding habitat guild, in White Sands NP upland habitat surveyed. Error bars are 95% confidence intervals.

Grassland breeding habitat guild

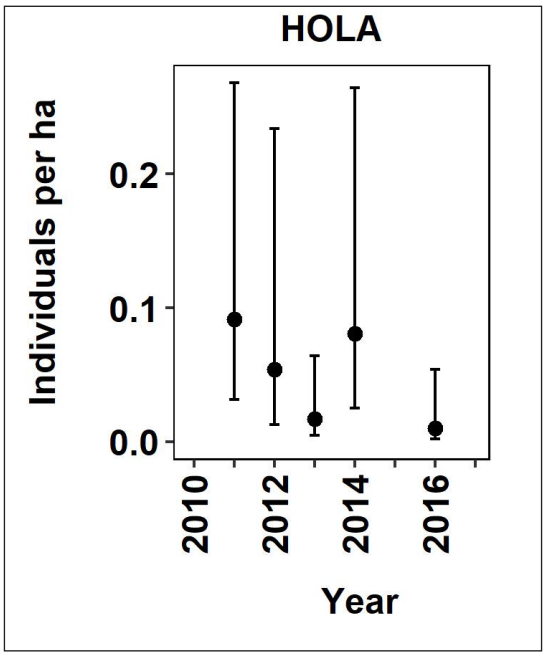


Figure E-29. Yearly estimates of density for HOLA (Horned Lark), a member of the grassland breeding habitat guild, in White Sands NP upland habitat surveyed. Error bars are 95% confidence intervals.

Shrubland breeding habitat guild

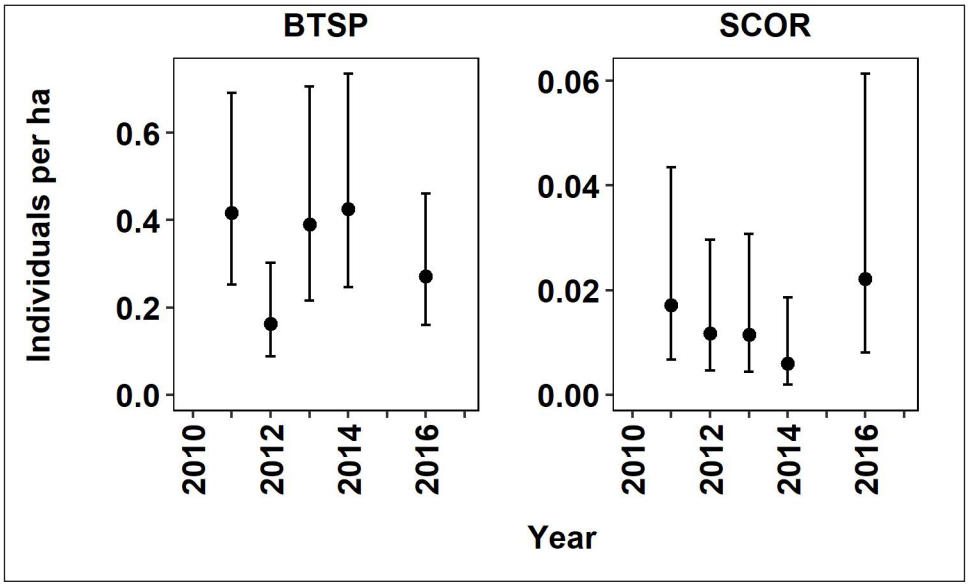


Figure E-30. Yearly estimates of density for BTSP (Black-throated Sparrow) and SCOR (Scott's Oriole), members of the shrubland breeding habitat guild, in White Sands NP upland habitat surveyed. Error bars are 95% confidence intervals.

Appendix F: Conservation Statuses in Bird Conservation Region 36 for Species in the Species Accounts.

Table F-1. Conservation statuses for birds detected in Amistad National Recreation Area (NRA) within Bird Conservation Region (BCR) 36, in which a portion of the park lies. The other portion of Amistad NRA and the other Chihuahuan Desert Network parks occur within BCR 35; conservation statuses for species in BCR 35 are provided in the Chapter 3 species accounts. Full names for conservation categories are provided below the table, and detailed descriptions of the categories are in Chapter 3 (Section 3.3.1.1).

Common Name	NatureServe G Rank	CCS-max	Federally listed	PT-r	TB-r	RD-b	% Pop	Regional Concern	Regional Stewardship	Texas State-listed
Ash-throated Flycatcher	G5	8	No	1	2	5	2.4	No	No	No
Bell's Vireo	G5	8	No	3	3	3	2.1	No	No	No
Bewick's Wren	G5	8	No	1	2	4	4.7	No	No	No
Black-tailed Gnatcatcher	G5	10	No	2	3	2	0.5	No	No	No
Black-throated Sparrow	G5	10	No	5	3	4	1.8	Yes	No	No
Blue Grosbeak	G5	8	No	3	3	3	0.4	No	No	No
Blue-gray Gnatcatcher	G5	9	No	1	3	2	0.2	No	No	No
Brewer's Sparrow	G5	7	No	–	–	–	–	No	No	No
Brown-headed Cowbird	G5	7	No	5	2	4	0.7	No	No	No
Cactus Wren	G5	7	No	5	3	4	4.1	Yes	No	No
Canyon Towhee	G5	7	No	3	2	1	–	No	No	No
Canyon Wren	G5	13	No	3	2	1	–	No	No	No
Cassin's Kingbird	G5	8	No	–	–	–	–	No	No	No
Cassin's Sparrow	G5	10	No	5	3	4	2.5	Yes	No	No
Cave Swallow	G5	8	No	1	1	5	14.7	No	No	No
Chihuahuan Raven	G5	11	No	5	3	4	1.7	Yes	No	No
Cliff Swallow	G5	18	No	1	2	3	0.4	No	No	No
Common Yellowthroat	G5	13	No	4	4	2	0.0	No	No	No
Curve-billed Thrasher	G5	8	No	5	3	5	4.9	Yes	No	No
Great-tailed Grackle	G5	12	No	2	1	5	7.4	No	No	No
Greater Roadrunner	G5	7	No	1	2	5	11.2	No	No	No

Definitions: CCS-max = Continental Combined Score; PT-r = Regional Population Trend; TB-r = Regional Threats-Breeding; RD-b = Regional Density-Breeding; % Pop = % of Global Population in BCR.

Note: Blank scores (–) in the table are because the species does not breed in BCR 36, so no score/rank was produced for that species in this BCR.

Table F-1, cont. Conservation statuses for birds detected in Amistad National Recreation Area within Bird Conservation Region (BCR) 36, in which a portion of the park lies.

Common Name	NatureServe G Rank	CCS-max	Federally listed	PT-r	TB-r	RD-b	% Pop	Regional Concern	Regional Stewardship	Texas State-listed
Green-tailed Towhee	G5	12	No	–	–	–	–	No	No	No
House Finch	G5	10	No	2	2	2	0.2	No	No	No
Loggerhead Shrike	G4	9	No	2	2	3	0.4	No	No	No
Mourning Dove	G5	8	No	4	3	5	1.6	Yes	No	No
Northern Cardinal	G5	8	No	1	2	4	1.2	No	No	No
Northern Mockingbird	G5	8	No	2	2	5	3.8	No	No	No
Painted Bunting	G5	8	No	5	3	5	8.5	Yes	No	No
Pyrrhuloxia	G5	11	No	5	3	5	17.9	Yes	No	No
Red-winged Blackbird	G5	12	No	4	3	5	1.8	Yes	No	No
Rock Wren	G5	12	No	3	2	1	–	No	No	No
Rufous-crowned Sparrow	G5	8	No	–	–	–	–	No	No	No
Scaled Quail	G5	7	No	5	3	4	2.5	Yes	No	No
Scott's Oriole	G5	10	No	–	–	–	–	No	No	No
Spotted Towhee	G5	11	No	–	–	–	–	No	No	No
Summer Tanager	G5	15	No	2	3	2	0.2	No	No	No
Verdin	G5	7	No	3	3	4	3.3	No	No	No
Western Kingbird	G5	11	No	1	2	2	0.6	No	No	No
White-winged Dove	G5	7	No	1	2	4	2.3	No	No	No
Yellow-breasted Chat	G5	4	No	2	3	2	0.1	No	No	No
Yellow-rumped Warbler	G5	8	No	–	–	–	–	No	No	No

Definitions: CCS-max = Continental Combined Score; PT-r = Regional Population Trend; TB-r = Regional Threats-Breeding; RD-b = Regional Density-Breeding; % Pop = % of Global Population in BCR.

Note: Blank scores (–) in the table are because the species does not breed in BCR 36, so no score/rank was produced for that species in this BCR.

Appendix G. Technical Details of Power Analysis.

This appendix describes the technical details of the power analysis for both species richness and occupancy. The results of the power analysis are contained in Chapter 4 of the report.

G.1 Technical Details of Species Richness Power Examination

For each year in each park-habitat, species richness was estimated using the first-order jackknife estimator with either transects or points as replicate surveys (see Chapter 2, Section 2.5.1). Using yearly estimates summarized in Chapter 3, we calculated the coefficient of variation (CV) of each yearly estimate, then averaged CVs across years for that park-habitat ("CV_Estimation") (Table G-1). The year-to-year variation in true richness was estimated for each park-habitat as the sample variance of the yearly richness estimates (i.e., total variability in estimates across years) minus the average estimation variance for that park-habitat combination (i.e., average standard error squared) (e.g., Skalski 2012). The year-to-year variation was then scaled as "CV_Year" (Table G-1).

For long-term trend detection, year-to-year variation in the parameter of interest (here, in park-habitat richness) can severely limit how soon a trend can be detected (Urquhart and Kincaid 1999). Estimating this source of variation accurately requires many years of data; 10 years is often seen as a minimum for getting meaningful estimates (Gray 2012). However, CHDN data to date includes only 4–7 years of data. Thus, our estimates of yearly variation have high uncertainty and are somewhat more likely to underestimate rather than overestimate longer-term variation (Gray 2012). Our results should be seen as helping examine relative differences in power for alternative design scenarios, not as precise estimates of park-habitat-specific power.

We used a simulation approach in R software (R Core Team 2019) to quantify power. For each temporal design (annual, 5-5, and 3-7)

Table G-1. Power calculations for CHDN species richness monitoring under annual revisit design based on detection of 3% per year decline in richness and log-linear regression trend analysis at alpha = 0.05. Estimates of yearly variation, average estimation variation, and baseline richness for CHDN species from richness analyses of birds classified as breeders in a park and surveyed effectively with point counts.

Park	Habitat	CV_Year	CV_Estimation	Baseline Richness	Years [2]	Richness Change [3]
Amistad NRA	Riparian	9	14	55	16	-21.2
	Upland	7	13	47	15	-17.2
Big Bend NP	Riparian	(8) [1]	11	46	14	-16.0
	Upland	9	12	39	15	-14.3
Carlsbad Caverns NP	Riparian	5	12	35	14	-12.2
	Upland	9	10	40	15	-14.7
Fort Davis NHS	Upland	10	12	39	16	-15.0
Guadalupe Mountains NP	Riparian	8	12	41	15	-15.0
	Upland	5	11	46	13	-15.0
White Sands NP	Upland	(9) [1]	8	30	14	-10.4

[1] Yearly variation was not estimable for Big Bend NP Riparian and White Sands NP Upland with the variance partitioning approach used; values in parentheses were used.

[2] Number of years of monitoring to achieve 0.80 power.

[3] Change in richness from baseline when power reaches 0.80.

and park-habitat combination, we simulated 1,000 replicate sets of richness measures, with 50 years for each replicate set. We specified a baseline richness value equal to the average richness estimate from analyses in this report for each park-habitat, and calculated "true" annual expected richness values based on a relative decrease of 3% per year from baseline richness for each park-habitat. Note that the 3-7 revisit design consists of three consecutive years of monitoring followed by seven years with no monitoring each decade.

For each year in each replicate, we simulated true richness by adding a random normal deviation from that year's expected richness. Specifically, we used that year's expected richness as the mean and used the CV_Year and baseline richness to set the standard deviation of a normal distribution to generate year-specific deviations in simulated true richness around the trend line. We then added random measurement error to produce a simulated richness estimate for that year. We generated this random measurement error from a normal distribution with a mean of zero. The CV_Estimation value for that park-habitat was used as the standard deviation of its measurement error distribution.

Starting in year 5 for each of the 1,000 replicates in each analysis scenario, we regressed the vectors of log-transformed simulated measured richness for years 1–5, years 1–6, ..., years 1–50 against the corresponding year vectors, and recorded the p-value for each test of the null hypothesis of no trend. For each scenario, we estimated power as the proportion of 1,000 replicates in which a trend was detected in year 5, 6, ..., 100. For each scenario, we recorded the first year in which the null hypothesis of no trend was correctly rejected in at least 80% of the replicates.

The values we used for CV_Year and CV_Estimation are estimates, and this produces uncertainty in each power estimate that we did not explicitly address. Had we formally done so, we expect that none of the power estimates for a given trend scenario would statistically differ among park-habitat combinations. Although we provide the park-habitat-specific estimates of the number of years needed to achieve power of 0.80 (Table G-1), in the power analysis results we emphasize general patterns across the three trend scenarios rather than park-habitat-specific variation. In addition, to examine how power would change with a less frequent revisit design than the annual design (i.e., 5-5 or 3-7), we reported results from just one park-habitat combination (Big Bend NP Upland), as we expected comparable patterns for all park-habitat combinations.

G.2 Technical Details of Occupancy Power Examination

The simulation approach used to estimate power for the hierarchical occupancy design was computer intensive, making it infeasible to examine power using estimates from every species-park-habitat combination. Moreover, species-park-habitat-specific power analyses were not warranted given low precision in the available estimates of occupancy and detection probability from CHDN data to date (see Chapter 3), as only gross differences in the occupancy estimates likely were meaningful. Therefore, we used a two-step approach. We used a simulation approach to examine a range of scenarios for baseline transect occupancy, conditional point occupancy, detection probability, number of transects, and number of points per transect, as well as for revisit schedule (annual and 3-7). We then matched CHDN species-park-habitat combinations to one of these general scenarios, using the point estimates of occupancy and detection probabilities from CHDN monitoring to date, to determine the most relevant simulation scenarios for a particular species in a particular park-habitat combination.

G.2.1 Simulation of general monitoring scenarios

First, we used simulations to estimate power to detect trend in transect occupancy for a range of general monitoring scenarios representing all combinations of the following values of simulation parameters:

- revisit design: annual and 3-7 designs
- number of transects per park-habitat: 8, 10, 12, 16, 20, 25, 30, 35, and 40
- number of points per transect: 9 and 16

- baseline transect occupancy: 0.10, 0.25, 0.50, 0.75, and 0.90
- conditional point occupancy: 0.10, 0.25, 0.50, 0.75, and 0.90
- detection probability per 2-minute survey interval: 0.25, 0.50, and 0.75.

Combining the various levels of the six attributes above resulted in 2,160 monitoring scenarios. For annual revisit scenarios, we assessed power after the following number of years of monitoring: 10, 15, 20, 25, 30, 35, 40, 45, and 50. For 3-7 revisit design simulations, we assessed power after 11, 13, 21, 23, 31, 33, 41, 43, 51, and 53 years of monitoring. As the 3-7 design assumed monitoring was conducted in years 1–3, 11–13, 21–23, etc., power increased in a stepwise pattern for this design, with no change in power in years 4–10, in years 14–20, etc., when no data collection would occur. For each year of power assessment in each scenario, we performed 100 replicate simulations, as each set of 100 replicates was computer intensive. This resulted in 800–900 replicates for examining power versus year of monitoring for each combination of survey design and occupancy/detectability parameters (e.g., for annual revisit simulations, 100 replicates each for simulated monitoring years 10, 15, 20, … 45, 50). For some combinations we ended up with one complete run and one partial run of simulation scripts, due to computer issues. Therefore, results included an extra set of 100 replicates for some monitoring scenarios. Collectively, this effort resulted in about 2 million replicate analyses for all scenarios combined.

For each monitoring scenario, we generated true transect occupancy at time *t* with the exponential change model $Psi_t = Psi_{baseline} \times e^{-0.03x(t-1)}$. For each year from 1 to 50 for annual revisit simulations, and for years 1 to 53 for combinations with the 3-7 revisit design, we generated transect occupancy, conditional point occupancy, and detection data per 2-minute interval (k = 3 intervals per point survey) as independent Bernoulli outcomes. This step used the scenario's specified probabilities of transect occupancy for that year, conditional point occupancy, and detection probability. Conditional point occupancy (Theta) was held constant (trend of 0.00 with no variability among transects or points) for all simulation years within a simulation combination, as was detection probability for all simulated surveys in the simulation combination.

Under the simulation model we implemented, probability of occupancy of a specific transect or point was independent of its occupancy status the previous year, and there was no heterogeneity in occupancy and detectability parameters within a 100-replicate simulation combination, except for the 3% relative decline per year in transect occupancy. We analyzed each of the ~2 million simulated data sets using the multi-scale, single-season, occupancy model with maximum likelihood inference in program "MARK" (White and Burnham 1999), using R package "RMark" (Laake 2013). The single-season model was used as in Gould (2015), with years "stacked" in the data set. For example, with 20 transects and 10 years of simulated data, the stacked data set consisted of 200 rows of transect-year detection histories, including a "year" covariate column. For each 3-7 revisit scenario, we subsetted simulated data so that the analyzed data set consisted of binary detection data only for the simulated years of sampling (e.g., after year 23 of monitoring, trend analysis included data for years 1, 2, 3, 11, 12, 13, 21, 22 and 23).

To keep automated simulations tractable and ensure estimable analysis models in long-running automated simulations, we fit one model to each data set, with Psi modeled as a logit-scale linear function of year (coded as a numeric variable), and with Theta and p assumed constant. For each replicate, we fit the model and conducted a Wald test of the null hypothesis of no trend (i.e., Ho: logit-scale trend coefficient = 0, with a Z-test statistic equal to the estimated trend coefficient value divided by its estimated standard error). As stated previously, alpha was set to 0.05 for all tests. For each combination of 100 replicates, we estimated power as the proportion of these 100 replicate tests that correctly rejected the null hypothesis of no trend in transect occupancy.

The single fitted model for each replicate was equivalent to the true model used to gener-

ate the data in assuming no heterogeneity or trend in Theta or p. It included no heterogeneity in Psi other than the year trend. This lack of heterogeneity included omitting auto-regressive effects of occupancy in the previous time, in contrast to the dynamic extinction-colonization model used for analysis earlier in this report (Chapters 2-3; MacKenzie et al. 2017). With small sample sizes of transects and detections in many of our simulation combinations, fitting a simple model assuming homogeneous parameters minimized issues with non-convergence, whether flagged by RMark or only detectable by inspecting parameter estimates and standard errors.

Another simplification is that our simulations assumed independent analyses of each park-habitat combination, rather than the integrated hierarchical model we used in Chapters 2–3. While the latter allows more precise information of detection probability by borrowing information about detection patterns across parks, our general results in Section 4.2.3.1 in Chapter 4 suggest that uncertainty in estimating detection probability per 2-minute interval is not a major constraint on power to detect trends in transect occupancy. Moreover, fitting more complex models to simulated data, including models integrating multiple park-habitats with varying occupancy parameter values, would have required manual examination of output from each set of models, or even more time-consuming Bayesian analyses, precluding running hundreds of thousands of simulations within an acceptable time frame. Our approach of using a simple general model for study design examinations is a common one (Skalski and Robson 1992, MacKenzie et al. 2017).

For examining species-level power patterns for individual park-habitats, we crosswalked species-park-habitat analysis results from Chapter 3 to line up with simulation scenarios described above. Specifically, using results described in Chapter 3 we categorized posterior median occupancy estimates with respect to the five baseline occupancy levels used in simulations, as follows: for occupancy estimates 0–0.175, we used the 0.10 simulation results; 0.175–0.375: 0.25 level; 0.375–0.675: 0.50 level; 0.675–0.85: 0.75 level; and 0.85–1.0: 0.90 level. For example, for Bell's Vireo at Big Bend NP Riparian, occupancy analysis from data collected to date produced median posterior occupancy estimates of 0.94 (transect) and 0.79 (conditional point). Therefore, we used power estimates from the simulated monitored scenarios with baseline occupancy of 0.90 and conditional point occupancy of 0.75 as applicable to Bell's Vireo at Big Bend NP Riparian. For detection probability, we grouped overall average posterior median p estimates of <0.375 as matching the 0.25 simulation level, matched estimates 0.375–0.675 with the 0.50 level, and matched estimates >0.675 with the 0.75 level. Current transect replication matched one of our transect simulation scenarios for most park-habitats (8 for Carlsbad Caverns NP Upland; 10 for Amistad NRA Riparian, Big Bend NP Riparian, Guadalupe Mountains NP Upland, and White Sands NP Upland; and 20 for Big Bend NP Upland). For Amistad NRA Upland, currently with 9 transects, we used simulation scenarios with 10 transects; given minor differences between general results for 8 versus 10 transects, this likely overestimated power for Amistad NRA Upland very slightly. Current numbers of points per transect matched with one of our simulation scenarios for each park-habitat (~9 for Amistad NRA and Big Bend NP Riparian, 16 for upland park-habitats with transect replication).

We examined a reduced number of simulation scenarios for park-habitats where point-scale occupancy is the focus (Fort Davis NHS Upland, Carlsbad Caverns NP and Guadalupe Mountains NP Riparian). For these park-habitats, we examined power of annual versus 3-7 revisit schedules. Simulations examined only the current number of points per park habitat (26 for Fort Davis NHS Upland, 8 for Carlsbad Caverns NP Riparian, 16 for Guadalupe Mountains NP Riparian) due to limited options for increasing the number of points in these park-habitats. The number of 2-minute survey intervals per point per year was set to 6, as the current design involves two visits of 6 minutes each (three 2-minute intervals per visit) in these park-habitats. All other analysis methods and summary steps mirrored those described above for park-habitats with transect-scale focus.

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Natural Resource Stewardship and Science
1201 Oak Ridge Drive, Suite 150
Fort Collins, Colorado 80525

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