

Binational avian monitoring, research, and capacity building in the Pinacate and Organ Pipe Cactus National Monument Biosphere Reserves

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Prepared for:

Krista Muddle
Regional Partnership Coordinator
Southwest Border Resource Protection Program
National Park Service - Intermountain Region
12795 W. Alameda Parkway
Lakewood, CO 80228
krista_muddle@nps.gov

Prepared by:

Aaron D. Flesch, Ph.D.
Research Scientist
School of Natural Resources and the Environment, and,
The Desert Laboratory on Tumamoc Hill
University of Arizona
1675 W. Anklam Road, Tucson, AZ 85745
flesch@ag.arizona.edu



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EXECUTIVE SUMMARY

This project addressed a broad suite of objectives focused on bird monitoring, linking bird monitoring in Organ Pipe Cactus National Monument (OPCNM) with efforts in the Pinacate Biosphere Reserve in Mexico, and building binational capacity for monitoring through trainings and outreach. Our primary objective was to understand changes in bird communities in OPCNM since the early 1990s and gather data in 2021 to foster these assessments. Although OPCNM is one of few National Park units with its own ecological monitoring program and had obtained extensive data on birds during standardized surveys, there had been little effort to analyze these data and understand changes in communities. Such gaps of knowledge are surprising because birds are excellent ecological indicators given close associations between individual species and specific resources and conditions, and because birds are efficient to survey across large areas. Our efforts provided the first comprehensive analysis of temporal changes in breeding bird communities across the entire monument, which is significant.

In 2021 with help from OPCNM ecologist Dr. Peter Holm, we completed point-count surveys at 25 sites located across the monument three times between late February and late May 2021. Our efforts in 2021 spanned 196 points and resulted in 6,382 bird detections totaling 7,722 individuals of 107 species. In Pinacate in 2021, University of Arizona staff and project partners also surveyed each of 10 transects 1-2 times during the breeding season, which resulted in 618 bird detections totaling 834 individuals of 60 species. In both reserves, we also surveyed for special status bird species including Golden Eagle. In OPCNM, we surveyed for Ferruginous Pygmy-Owls at 45 stations totaling 360 mins of effort, and covered most areas within ~500 m of locations where the species had been detected in the past.

We combined 2021 information from OPCNM with past data to generate a final data product that included effort totaling 126 site years and 427 site visits across nearly a 30-year period (1993-2021). Past data we considered was from 19 sites, included information from sites visited a minimum of three times within a given year, and data gathered during both point counts and belt-transect surveys. Despite numerous requests, we failed to obtain monitoring data from NPS' Sonoran Desert Network (SODN) and hence censored 2021 data that we gathered along six SODN transects. Lack of these data combined past effort and visitation schedules in OPCNM resulted in a broad temporal gap in sampling between 2004 and 2021. Regardless, since 1993, a remarkable total of 62,429 individual bird detections of 53 focal breeding species were considered in analyses. We coupled bird data with information from 15 weather stations across OPCNM, satellite-derived estimates of vegetation cover provided by project collaborators, and other information to describe environmental variation across the 19 study sites.

To describe spatiotemporal variation in bird communities in OPCNM and associations between communities and environmental factors, we largely used multivariate techniques. We used nonmetric multidimensional scaling on a Sørensen distance matrix of relative abundances of each species at each site in years when ≥ 3 visits were made per site, and assessed associations with environmental factors by fitting vectors to ordination results and computing Pearson correlation coefficients. To assess temporal variation in communities across time, we fit vectors for year and time period to ordination results and considered three time periods (1990s, early 2000s, and 2021). We also used multi-response permutation procedures, blocked indicator species analysis, and comparisons of occurrence probabilities for each the 53 focal breeding species to compare communities across the three time periods. To understand how past changes in methods (e.g. belts vs. points) and assumptions regarding relative abundance calculations influenced results, we used Mantel tests to assess differences in ordination results based on two alternate datasets, one based on presence-absence data and another based on relative abundance computed with bird observations from within 50 meters of points (vs. at unlimited distances).

Ordination methods provided both ecologically and spatially coherent results, and some novel insights into associations between bird communities and environmental factors. Over time, bird communities in OPCNM shifted in ways consistent with increasing aridification, which is not surprising given

expectations linked to climate change and given that the year prior to 2021 surveys was exceptionally dry. Fortunately, however, community shifts we observed were much less extreme than those observed recently in the neighboring Mohave Desert. Temporal shifts in communities were underpinned by losses of species dependent on riparian woodlands and dense shrubs (e.g., Bell's Vireo, Rufous-winged Sparrow), and gains in cavity-dependent species (e.g., woodpeckers), species that use open country (e.g., Say's Phoebe), and generalists (e.g., Common Raven). Bird species within these habitat groups also typically had lower or higher occurrence probabilities in 2021 compared to those observed historically depending on species' habitat affinities. Auspiciously, the nest parasitic Brown-headed Cowbird had much lower occurrence probabilities in 2021 than in prior years suggesting broad declines across OPCNM. Interestingly, variation in bird communities was more strongly associated with precipitation than with temperature, and associations were strongest for annual versus seasonal estimates of precipitation. Moreover, precipitation measured by broader moving averages across time was increasingly associated with variation in bird communities suggesting its effects were linked to changes in climate rather than specific weather events. Given a long temporal gap in monitoring in the 2000s and extreme drought prior to recent 2021 surveys, we are unsure whether patterns we observed are broadly representative of current bird communities. Additional surveys, more refined environmental measurements, and supplementary analytical tools such as occupancy modeling can improve future inferences.

Survey efforts in 2021 also confirmed presence of at least one individual Golden Eagle in suitable breeding habitat during the breeding season in both OPCNM and Pinacate, provided the first observations of the Ferruginous Pygmy-Owl in OPCNM since early 2015, what may be the first observation of the Nutting's Flycatcher in OPCNM, and many other significant observations. In Mexico, we were successful in standardizing methods used in each reserve so that data are comparable and expanding the spatial scope of monitoring. Additionally, we trained local biologists in the application of point counts and bird identification, implemented a well-attended educational event on birds and conservation, and established important relationships with partners that will persist beyond the life of this project. Future efforts combined with additional data will continue to link monitoring across the border, elucidate the patterns and drivers of changes in bird communities, and highlight the implications for conservation and management.

ACKNOWLEDGMENTS

This project was fostered by numerous partners and collaborators. Dr. Peter Holm of Organ Pipe Cactus National Monument (OPCNM) made major contributions by coordinating efforts among National Park Service (NPS) staff, providing information on methods and study sites, and data on birds, vegetation, and climate, and fostering permits and use of office space. Dr. Holm also made a large contribution to data collection by completing 35% of transect surveys during the 2021 field season. Also in OPCNM, Danny Martin coordinated surveys of Ferruginous Pygmy-Owls with UA staff, completed desert thrasher surveys, and he and Adam Fuest assisted Dr. Holm with bird surveys and participated in training activities. Ami Pate of OPCNM provided data on access and helped develop approaches to estimate cover of legal and illegal roads and trails and vegetation cover that will hopefully be provided for future efforts. University of Arizona field technician Fernando Diaz performed 35% of transect surveys in OPCNM in 2021, entered and proofed field data, and did a fine job in the field and office. Dr. Miguel Villarreal of U.S. Geological Survey (USGS), Western Geographic Science Center, provided timely and valuable time-series data on woody vegetation cover from Landsat images around point count stations, and Dr. Seth Munson of USGS also helped foster efforts through their prior work. Eric Verwys of the Tohono O'odham Nation (TON) Natural Resources Department graciously fostered access for UA and NPS staff through the TON to portions of OPCNM, and assisted surveys of Ferruginous Pygmy-Owls.

In Mexico, I am grateful to a large number of collaborators. Mr. Miguel Angel Grageda García of University of Arizona, and formally Pinacate biologist with the National Commission of Protected Areas (e.g., Comisión Nacional de Áreas Naturales Protegidas or CONANP), made major contributions by: 1) coordinating efforts with CONANP, 2) assisting with organizing and implementing training and workshop events with Mexico project staff and collaborators, 3) performing surveys of point transects in Pinacate, and 4) preparing a summary and analyses of field effort and bird observations in Pinacate based on data we gathered during this project and his past efforts. We are grateful to the CEDO Intercultural Center for the Study of Deserts and Oceans in Puerto Peñasco, Sonora, Mexico for partnering with us on this project. Peggy Boyer provided initial support but retired before project initiation, and current CEDO executive director Dr. Nélida Barajas Acosta provided a broad range of support. She helped galvanize community participation in workshops and training activities in Pinacate, added important content to events, and recruited CEDO biologist Ángeles Yazmín Sánchez Cruz to assist with bird surveys in Pinacate. CEDO staff member Abelardo Castillo Rosas, retired U.S. Fish and Wildlife Service biologist and CEDO volunteer Mark Kaib, and many others from CEDO provided companionship in the field and supported and participated in field work and workshop activities in Mexico. Pinacate Acting Director, Horacio Ortega, and other CONANP staff helped organize logistics and access in Pinacate and provided permits and access to field buildings. Finally, I am grateful to Krista Muddle, Steven Rossi, and Todd Wilson of NPS' Southwest Border Resource Protection Program for support and administrative help. Peter Holm provided helpful reviews of this report that improved its content.

On the cover: Participants that attended workshops at Pinacate Biosphere Reserve in Mexico in Feb. 2021 (left) and desert-scrub along an avian monitoring transect in Organ Pipe Cactus National Monument with view of the Ajo Mountains in the background, May 2021 (right).

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INTRODUCTION

Organ Pipe Cactus National Monument (OPCNM) and the Pinacate and Gran Desierto de Altar Biosphere Reserve (Pinacate) in adjacent Mexico encompass significant portions of the largest contiguous protected area in the Americas (Felger and Broyles 2007). Biological and other resources in OPCNM and Pinacate are of great binational and global significance as evidenced by designations as UNESCO Biosphere Reserves and Pinacate is also a World Heritage Site. Despite the significance of this transboundary region to conservation and its remarkable biodiversity, these and other nearby protected areas in the Sonoran Desert face a broad range of ecological threats that may not be adequately buffered by existing protection mechanisms. In this hyperarid region, low soil moisture, limited vegetation cover, extreme heat, and unpredictable rainfall result in many species persisting near the limits of their ecological tolerances even despite special adaptations to these harsh environmental conditions. In such settings, small environmental changes linked to anthropogenic disturbance, climate warming or drying, and other stressors can pose independent or even synergistic threats that can reduce reproduction or survival, drive population declines, and impact community composition and structure (Holmgren et al. 2006, Mantyka-Pringle et al. 2012, Flesch et al. 2015). In the neighboring Mojave Desert over the last century, for example, recent work has documented the collapse of bird communities as a likely result of climate change, which contrasts with greater stability for communities of small mammals that can behaviorally buffer climate impacts (Iknayan and Beissinger 2018, Riddell et al. 2019, 2021). Similarly in OPCNM, climate warming and drying across a recent 25-year period were associated with marked changes in lizard communities characterized by declines of species with traits that augment the vulnerability of individuals to harsh weather and increases in species with more favorable traits, suggesting large impacts of climatic change (Flesch et al. 2017). Climate warming and drying in this region of the Sonoran Desert have also been linked to reductions in tree and shrub cover, and these and other stressors such as soil disturbance from illegal immigration and related activities could be exacerbating these impacts even within protected areas such as OPCNM (Webb et al. 2013, Munson et al. 2012, 2016, Villarreal et al. 2016). These and other threats have broad implications for conservation and management in the Sonoran Desert and in other arid regions globally.

Understanding and mitigating the impacts of climate change, anthropogenic disturbance, and other stressors in protected areas within the Sonoran Desert depends on focused natural resource monitoring, periodic assessment of monitoring data, and application of resulting inferences to management. To help address these needs, OPCNM is well positioned as one of the first National Park units to implement its own ecological monitoring program. Since the early 1980s, natural resource staff and collaborators have developed and implemented efforts to monitor various environmental attributes and resources including climate and vegetation, and various plant and vertebrate taxa (Bennett et al. 1990, OPCNM 2006). Recent and past studies have analyzed some of the resulting long-term datasets and generated important inferences on the status of resources and the patterns and drivers of changes in vegetation and wildlife (Rosen 2000, OPCNM 2006, Flesch 2008, Munson et al. 2012, Flesch et al. 2017, Larios et al. 2020). Despite presence of these data, there has been little effort to assess these patterns for some taxa including birds. Hence, there is little information on whether bird communities have changed across time or space in OPCNM, or how stressors such as climate change are impacting communities. Similarly, efforts to inventory bird communities in neighboring Pinacate have been limited to the past few years and have considered few sites across this vast Biosphere Reserve (M. Grageda, *pers. comm.*). Limited effort to understand changes in bird communities despite presence of data is notable because among vertebrate taxa birds are ideal indicators of ecological change (Hutto 1998). This is because of close associations between specific bird species and a wide range of resources and conditions linked to foraging, nesting, and other requirements, and because birds are highly efficient to survey (Bibby et al. 1992, Canterbury 2000, Bryce et al. 2002). Thus, monitoring bird communities across time and space can provide important insights into the presence and magnitude of changes in ecological resources and conditions, and help guide management (Flesch 2018a). As a result, the Sonoran Desert Network's (SODN) Inventory and Monitoring program ranked land birds as the highest priority for vertebrate monitoring among all animal

groups (Mau-Crimmins et al. 2005). Given evidence of recent collapse of desert bird communities in the nearby Mohave Desert (e.g., Iknayan and Beissinger 2018), major new development of security infrastructure along the international border (Peters et al. 2018), and recent droughts, bird communities in the region face major threats, which highlights needs for current assessments in OPCNM and beyond.

As a basis for these assessments, there is a long history of standardized avian monitoring in OPCNM that was built on a foundation of past studies of bird communities that began in 1894 (see review by Schmidt et al. 2007). With regard to standardized avian monitoring, field work linked to these efforts involved surveys of belt transects in 1987, 1989, and 1991-1995 (Johnson and Hiatt 1992, OPCNM 1995), and point counts in 1995-2004, 2007-2013, and 2015 (Tibbitts 2006, Halterman and Laymon 2000, Flesch 2009, Ali et al. 2013, Peter Holm *pers. comm.*; Table 1). Despite presence of these data, field methods have varied over time, point-count protocols linked to count time, station spacing, and distance estimation have also varied, and visitation to various long-term monitoring sites has been highly sporadic with major gaps in sampling (see Tibbitts 2006). In some cases, initial sets of monitoring sites were not revisited with regularity and new sites were created both in the late 1990s with implementation of OPCNM's Ecological Monitoring Program (EMP; OPCNM 2006, Tibbitts 2006) and with subsequent efforts by SODN that begin in 2007 (Powell et al. 2007). These and other issues presented a range of challenges for data analyses and assessments of population and community change across the monument and limited some of the analytical tools at our disposal, which this project was among the first to confront. Nonetheless valuable insights were gained from past data, and additional avenues for generating inferences in the future exist.

Objectives

This project focused on a broad set of objectives focused on leveraging past data gathered by NPS and collaborators, and integrating this information with current data we gathered during 2021. We strove to derive inferences on the patterns and drivers of bird community change, link efforts in OPCNM with those across the international border in neighboring Pinacate, and provide training and outreach activities in the U.S. and Mexico. In the U.S., our main objectives were to: 1) gather current data on breeding bird communities during the 2021 field season in OPCNM to extend existing time-series data, 2) combine 2021 data with that from other standardized monitoring efforts from past years in OPCNM and assess population and community trends of breeding birds, 3) evaluate the influence of variation in climate and weather, anthropogenic disturbance, vegetation and landform, and other potential drivers on bird communities, and 4) assess implications for management and conservation. This work involved extensive field effort in late winter and spring of 2021 across OPCNM to survey breeding bird communities and surveys of several special status species, which was aided by and coordinated with ongoing efforts by NPS staff. To address objective two above, extensive effort was required to check, correct, and standardize past data from OPCNM so that they could be combined into a single data product for analyses. Field work and data management were pursued in ways to provide training and learning opportunities for NPS staff in field methods for monitoring bird populations and the ecology of avian systems to help add capacity to park staff based on experiences gained over 25 years of similar work in the region by University of Arizona staff. Specific questions we addressed included: 1) how have breeding bird communities changed overtime in OPCNM?, 2) is variation in bird populations and overall community composition and structure associated with spatiotemporal variation in annual and seasonal weather, vegetation, or anthropogenic disturbance?, and 3) what is the current status of priority species such as Golden Eagle (*Aquila chrysaetos*), Cactus Ferruginous Pygmy-Owl (*Glaucidium brasilianum cactorum*), and desert thrashers (*Toxostoma* spp.) in OPCNM?

In Mexico, we focused on building cross-border collaborations and capacity in Pinacate and the surrounding community in Mexico to address current and future challenges. This work involved the following main objectives: 1) establish and continue similar avian monitoring efforts in Pinacate so as to link efforts with those in OPCNM, 2) review existing methods and expand monitoring to additional sites,

3) inventory bird communities in Pinacate with the use of point counts and surveys of special status species, 4) train Pinacate staff and collaborators in methods to sample birds in the field, and 5) provide outreach and education to the surrounding community in the form of workshops, presentations, and educational materials. Although OPCNM has a long history of collaboration and a “sister-park” relationship with Pinacate, it only included joint monitoring of climate, vegetation, reptiles, and mammals, but not birds. Resource managers at OPCNM and Pinacate had expressed needs to resume bird monitoring and establish links through similar efforts in Pinacate. To accomplish these goals, we recruited the CEDO Intercultural Center for the Study of Deserts and Oceans based in nearby Puerto Peñasco, Sonora, (hereafter “CEDO”) and Mr. Miguel Angel Grageda García. Miguel was formerly a biologist in Pinacate and is now a doctoral student at University of Arizona, and implemented bird monitoring in Pinacate in 2015, 2016, and 2017. Hence, we expanded on the foundation Miguel built to help achieve project goals. CEDO is a nonprofit organization focused on understanding and protecting natural resources and cultures of the Sonoran Desert and Sea of Cortez. CEDO’s mission is to bring together people, knowledge and solutions for vibrant communities and resilient ecosystems, and thus they were well situated to provide a bridge into local communities for trainings and workshops, and a staff biologist and volunteers to assist with field surveys in Pinacate. This final project report summarizes our findings and accomplishments during this effort, and outlines future actions that can help foster bird conservation and monitoring in the region in the future.

METHODS

We employed a variety of methods linked to specific project goals and activities. Below we describe methods in sections linked to project goals:

Outreach and Education

These efforts focused on experiential techniques to both train field staff in bird identification and field methods to gather point count data in the U.S. and Mexico. In each nation, we first reviewed field protocols, sampling designs, and past efforts implemented in OPCNM and Pinacate with project partners to develop a list of 2021 study sites and refine methods for 2021. These efforts culminated in a field-training session in late February 2021 in OPCNM for NPS staff that was attended by three NPS biologists. Subsequently, we reviewed data sheets and discussed further standardization of protocols and reviewed species identifications in the office several times following completion of morning field work. Finally, we trained a UA technician, Fernando Diaz, in field methods during the course of five field days. In Pinacate, we developed a presentation on bird ecology and distribution in the reserve for CEDO and reserve staff, collaborators, and members of the community (Appendix A). This activity was followed by a presentation and discussion on proposed field methods, point count procedures, study design considerations, analyses linked to bird monitoring, past efforts in OPCNM and the importance of connecting them across the border. Following these presentations, we demonstrated field methods to CEDO biologists and other participants and worked with them on bird identification and implementation of field methods. CEDO staff also led efforts to develop an informational and educational pamphlet on birds, ecology, and conservation for students, adults, and local ranchers. This work was begun but not finished during the project period and will hopefully be continued in the future during phase II efforts.

Design, Surveys, and Data

Two primary field methods have been used to sample birds in OPCNM since 1987, with various modifications to protocols linked to count time, station spacing, number of visits, and other details over time. These topics were reviewed in detail by Tim Tibbitts (2006) and are discussed here in sufficient detail to understand field and analyses procedures we selected in 2021 and to provide important background. Addressing variation in past methods was a major challenge for this project, as was

developing efficient field and analyses procedures given various protocol changes. Belt-transect methods in 1987-1995 involved one or more observers walking ~1000-1500 meter (m) long transects and recording birds seen or heard within belts of 20-60 m, but other species and individuals detected incidentally outside belts were also recorded. Point counts in OPCNM were first implemented by Halterman and Laymon (2000) in 1995 and 1996. They made six visits per year at eight sites, with efforts in 1995 overlapping belt transect at four sites enabling comparisons. Point counts involve recording birds seen or heard at fixed points at which observers were stationary and then moving quickly to subsequent points. Points in OPCNM were arranged along transects and spaced at distances of 250-500 m. In 1997-2004, Tibbitts and colleagues implemented point counts as part of OPCNM's EMP at as many as 11 sites per year but several modifications to procedures were made over time and as many as three visits per site per year were made in most years (Table 1). Following suspension of bird monitoring in OPCNM after the 2004 field season, subsequent efforts by SODN also used point counts. These efforts, however, involved more contemporary variable-distance methods where linear distances to each bird observed from points were estimated to the nearest meter with use of laser rangefinders, as is recommended for distance sampling procedures (Buckland et al. 2001). Prior point-count efforts between 1995-2004 recorded birds only in 1-4, 50- to 100-m wide distance bands beyond which unlimited distances were noted (e.g., 0-50, 0-100, >100, etc.) and bands that were used varied in 1995-1996, 1997, 1998, and 1999-2004. These inconsistencies produced a dataset that was not suitable for estimating densities with distance sampling techniques. Moreover, SODN focused on six new sites in OPCNM and did not revisit any long-term monitoring sites used by OPCNM during prior efforts. Use of new study sites combined with sporadic visitation schedules at core sites produced unbalanced efforts that are summarized in Table 1. Following review of all methods and protocols, we decided to use SODN version 1.02 of the landbird monitoring protocol described by Powell et al. (2007) for application in OPCNM in 2021 (see details below). Similar efforts were made in Pinacate although past data were much sparser and hence we used the same protocol to foster binational comparisons.

As an initial step to launching this project, we requested all available bird data from OPCNM and from SODN. Data were then evaluated to select an optimal set of study sites for field efforts in 2021, and to quality assess and quality control past data, standardize attributes, tabulate information on methods and procedures such as count time, and foster analyses. We promptly received data from OPCNM in four sets of files that corresponded to belt transects from 1987 and 1989 (Johnson and Hiatt 1992) and 1991-1995 (OPCNM 1995), and point counts from 1995-1996 (Halterman and Laymon 2000) and 1997-2004 (Tibbitts 2006), and reports associated with each effort. Despite more than a year of requests, we were unable to obtain point-count data gathered in OPCNM by SODN in years 2007-2013 and 2015 during the project period. We first made requests early in the project period in November 2019 to Network Manager Andy Hubbard and then to SODN Data Manager Helen Thomas. Subsequent phone conversations with Ms. Thomas were positive and noted SODN's intention to share data in a timely manner. Several subsequent requests were made in spring and summer 2021 while we synthesized data, but we received no data from SODN, nor were these data made available between summer 2021 and early 2022 while we worked to finalize this report. Evidence of our effort is provided in Appendix B. OPCNM staff and past reporting (Ali et al. 2013) indicated the years that SODN sites were visited (Table 1).

To select study sites in OPCNM, we worked collaboratively with Dr. Peter Holm. Based on a detailed review of sites surveyed and past visitation schedules, and our goal of sampling as spatially broad an area as possible, we chose to gather 2021 data at 25 sites in OPCNM (Table 2). This included all past avian monitoring sites including the six new SODN sites, but not five sites that had been visited in only 1-2 early years (Arch Canyon, Armenta Ranch, Growler Valley 2, Lost Cabin, Neolloydia Site). These 25 sites were then surveyed three times between late February and late May, which is when most bird species breed in OPCNM and when the bulk of past surveys were implemented. Locations of transects are mapped in Figure 1. To account for spatial differences between the location of belt transects that had not yet been replaced with point counts, we used historic maps of belts from NPS files to select a set of point count stations spaced 250 m apart that best overlapped belts and the habitat types they covered to

maximize comparability. In Pinacate, we reviewed information on the location and timing of past efforts provided by Miguel Grageda to evaluate the general habitat types covered. Past bird monitoring spanned eight sites in the reserve to which we added two additional sites to cover unrepresented environments: one at Cono Rojo in well-developed desert scrub on lava flows and another across scrub-dominated sand dunes along the trail northwest of the visitor center (Figure 2). Once an optimal list of study sites were developed, we reviewed and further standardized field protocols and issues linked to count time, distance between stations, data recording, and other attributes to maximize comparability of past and current data. Surveys in Pinacate were timed somewhat earlier (mid Feb.-May) because breeding begins earlier in these lower-elevation environments. We planned to survey Pinacate transects three times, but limited availability of Mexican collaborators and other issues typically resulted in two surveys per transect.

Point Counts: Daily field schedules for each surveyor involved visiting a set of 7-8 points each morning, starting surveys ~15 minutes before local sunrise time and completing work within 2.5-3 hours after sunrise. During counts, all birds seen or heard at each point were recorded during an 8-minute count period. Bird observations were noted by one-minute periods to allow comparisons with other survey efforts, and birds detected before and after counts were noted as species detected along transects but not during counts. We recorded all birds, regardless of detection distance from the surveyor with birds flying overhead recorded with a designation of “F” and distances measured to the initial location of detection. When conducting a point-transect survey, observers attempted to obtain an “instantaneous count” of the birds present. Birds that were flushed from the area around a point were recorded upon arrival at their initial distances and included as within count period birds, and counts started as soon as observer arrived at points. Once counts were completed, observers located successive points with use of handheld global positioning systems. While walking from one point to the next, we searched for species not recorded during the count period and after counts noted evidence of breeding of all species we detected. More detail is provided by Powell et al. (2007).

Surveys of Special Status Species: In OPCNM, we performed surveys for two special status species: Ferruginous Pygmy-Owl and Golden Eagle. We also proposed desert thrasher surveys, but this work was already planned and completed in 2021 by NPS biologist Danny Martin and will be reported elsewhere. There is little information on Golden Eagle in OPCNM as it occurs at very low densities and hence is rarely detected during point counts, which in this case is not an efficient survey method. To survey for the Golden Eagle, we established constant-effort observation posts near large cliff faces suitable for nesting in the Bates and Ajo mountains, and performed timed surveys of >1 hour during which we carefully watched the sky and surrounding area for eagles and other raptors. In contrast, there is a great deal of information on the status and distribution of the Ferruginous Pygmy-Owl in OPCNM. This species was the focus of survey efforts since the late 1990s by NPS, but has not been detected in OPCNM since 2015 (Hough 2015). Before pygmy-owl surveys, we evaluated NPS data files on the location of all past detections that totaled 42 localities, and overlaid our 25 bird monitoring point transects to assess where we could efficiently complement concurrent efforts by NPS staff. We also reviewed habitat maps and survey routes prepared by Danny Martin and our own habitat evaluations to select areas of potential breeding habitat that had not been surveyed. To enhance efficiency and optimize coverage, pygmy-owl surveys by UA staff were implemented in ways that took advantage of travel already required to visit point transects and in the process, survey various historical localities and other potential habitat for pygmy-owls. Surveys were not done during point counts because broadcasting owl calls can affect songbird behavior and bias results. Instead, we timed pygmy-owl surveys during early morning hours ~20-60 mins before the start of point counts, and often after point counts while walking back over transects. To survey owls, we used a protocol similar to that recommended by the U.S. Fish and Wildlife Service (2000) but that is more efficient based on patterns of response behavior and detection probability of >500 individuals (Flesch and Steidl 2007, Flesch 2018b). Survey times were sometimes outside the recommended periods due to time required to complete point counts but all effort was during low winds and low temperatures when pygmy-owls remain highly detectable during our March-May survey period.

In Pinacate, we also surveyed special status species including Golden Eagle and other cliff-nesting birds such as Prairie Falcon (see Table 3 for Latin names). This work was focused at cinder cones, craters, and the high peaks region, which provide sufficient sheltered cliff faces and other structures to support these nesting raptors and other cliff-dependent birds. We established constant-effort observation posts near large cliff faces suitable for nesting near each of these landforms in an opportunistic manner, and surveyed them across the day by recording all birds detected and behaviors. No pygmy-owl surveys were conducted in Pinacate because habitat was limited, likely not present, and because this species has not been observed in the reserve (Flesch 2003).

Environmental Measurements

To provide essential context for understanding how environmental variation and change influences bird communities, we sought to obtain measurements of various environmental attributes from project collaborators. We considered the elevation, latitude (UTM N), and longitude (UTM E) of each point count station that we averaged at the transect scale. We classified landforms (valley bottom, bajada, rockslope-canyon), vegetation formation (woodland, scrubland, mixed), and hydrologic type (riparian, upland, mixed) by using aerial imagery in Google Earth to assign stations to each of these general environmental categories and then classified transects based on the predominate state. To quantify impacts of border-related and other forms of land use by humans, we developed an approach with OPCNM Geographer Ami Pate to estimate density of both legal and illegal roads and trails around points across time. These measurements were to be based on OPCNM data on roads and trails and other data NPS obtained on illegal roads and trails (e.g., Sharp and Gimblett 2009) during three periods across time. Such estimates, however, were not generated during the project period due to other demands on NPS staff time, but will hopefully be completed for future application. Hence, we developed categorical ranks of disturbance classified on a scale from 0-3. Sites with no observed disturbance were ranked zero, sites with low disturbance (e.g., far from the border and maps of trails and roads) were ranked one, sites with moderate disturbance (within 5 km of the border) were ranked 2, and sites with high disturbance (within 1 km of the border where roads had recently been widened for border wall construction) were ranked 3.

Data on spatiotemporal variation in weather is useful for assessing changes in wildlife communities, and fortunately OPCNM has monitored weather since at least 1982 at a large number of stations. To describe variation in weather, we used monthly data on mean temperature from 12 weather stations and total precipitation (P) from 20 stations or rainfall gauges across OPCNM. These stations were selected from a broader set of as many as 33 weather stations by censoring those with >40% of missing monthly values since 1988. In time series data from weather stations, missing values are often common due to equipment errors or failures, or stations being abandoned or repositioned over time. In OPCNM, monthly values of P were censored if there were missing values and significant (>0.1 inches) rainfall at neighboring stations that suggested high likelihood of unmeasured rainfall. For temperature (T), monthly values were censored if there were 10 or more missing daily values in a month. A total of 18.2% and 14.0% of monthly records were missing from the full T and P datasets since 1988, respectively. To complete time series data for weather, we estimated missing values by fitting linear mixed-effects models with various fixed effects selected using backwards elimination, and station identity as a random effect. For T , we fit latitude, longitude, elevation, and latitude² as continuous fixed effects, and month and year as categorical fixed effects. This model explained 96.1% of variation in mean monthly T and yielded predictions that differed from known values by a mean of $<0.001 \pm 1.5$ deg. ($\pm$ standard deviation). For P , we fit latitude, longitude, and elevation as continuous fixed effects, and month, year, landform, and weather station type (e.g., rain gauge vs. full station) as categorical fixed effects. This model explained 25.6% of variation in total monthly P and yielded predictions that differed from known values by a mean of 0.001 ± 0.9 inches. Once missing values were estimated, we paired each bird transect with the closest T or P station based on proximity and elevation. Once paired with all available site years of bird data, the final weather data product was from 18 weather stations (Figure 1) with only 10.0% and 12.4% of monthly values predicted (vs. observed) for T and P , respectively. . We used weather data to estimate a small set of weather

attributes that we expected could influence variation in bird communities. For P , this included total annual P from March of the prior year through February of the current year (e.g., 12 months before survey period), prior warm-season P from April through September one year prior, recent cool-season P from prior October through March of the current year, and running averages of annual P over the prior 2, 3, 4, and 5 years. For T , we computed mean annual T (MAT), prior warm-season T , recent cool-season T , and running averages of MAT in the same periods as for P , and T of the hottest and coldest months of the prior year.

Vegetation cover is a fundamental aspect of wildlife habitat but often challenging to measure in the field across large areas. Despite its importance, we lacked resources to measure vegetation in the field but made special efforts to obtain relevant data from NPS and other sources. We first sought products on vegetation cover and height around point count stations that had been derived from recently acquired LiDAR data by Ami Pate for 2020 or 2021, but could not obtain them. We also considered data from OPCNM's vegetation monitoring program that uses line intercept sampling of vegetation cover along 40 transects at 19 sites and overlapped the range of years that birds were monitored. To explore these data, we considered cover from plots that had been measured during at least three years to assess changes across time of various life-form groups (e.g., trees, shrubs, etc.). These analyses revealed no trend in shrub cover, small declines in sub-shrub cover, and surprisingly, increases in tree cover across time. Inferences, however, were linked only to localized areas of 20 x 50 m and rarely overlapped point transects used for birds, which limited application for explaining wildlife communities at broader scales. To obtain more useful estimates, we assessed vegetation cover at broader scales by collaborating with Drs. Seth Munson and Miguel Villarreal of U.S. Geological Survey (USGS). In prior work (see Munson et al. 2016) they used Landsat Thematic Mapper images from June and September 1989, 1995, 1999, 2005, and 2009, field data, and modeling to estimate cover of creosote bush (*Larrea tridentata*) and leguminous trees at a scale of 30 m across the monument. We used these data to extract mean cover of each type of vegetation in each year within 150-m buffers around point count stations, averaged estimates at the transect scale, and computed total woody cover by summing estimates between types. Data from 1995-2009 were then matched with the closest years of bird data. Hence, bird data from 1993-1998 were linked to vegetation estimates from 1995, that from 1999-2001 to 1999, 2002-2004 to 2005, and that from 2021 was matched with estimates from 2009, which we assumed represented current conditions despite as much of a 12-year gap. To assess relationships between bird communities and vegetation cover, we considered raw estimates of vegetation cover in each period that represented spatiotemporal variation, and computed percent change in cover during each period from mean cover across all periods that represented just temporal variation. Estimates at the point scale were averaged for each site.

ANALYSES

Data and Design

We performed a detailed review of past bird data to correct data entry errors, foster consistency, and join data from various sources into one product. These time-intensive and largely unbudgeted tasks included standardizing sites names, species codes, and numerical and date formats, identifying stations, correcting various data entry errors, tabulating count times and other details linked to changes in methods, standardizing data and the recording for flyovers, and other tasks. Based on detailed evaluations, we chose to censor all belt transect data from 1987 and 1989 because survey effort was often implemented later in the breeding season (June and July) than subsequent efforts, and because raw field data were not available but only summaries from NPS files and photocopied reports. We contacted R. Roy Johnson in an effort to obtain original data sheets but they were no longer in his possession. We also censored data from years and sites during which fewer than three visits were made to a site within a given year. This minimum number of visits spread across the late February through May (or rarely early June) field season was deemed necessary to provide a reliable sample of communities, and because in some years (e.g.,

1991, 1992, 1997) only single visits were made to sites often early in the season before some migratory breeders had arrived (Table 1). We generated a list of regularly occurring diurnal breeding bird species on which we focused analyses by evaluating various species lists for OPCNM (see Schmidt et al. 2007) and our observations from 2021. This list included 53 breeding landbird species (Table 3) for which there was evidence of breeding in OPCNM, and eliminated species with just 1-2 prior records during standardized surveys and species that tend to breed after the field season such as Blue Grosbeak (*Passerina caerulea*) and Varied Bunting (*P. versicolor*). All inferences reported here focus on these 53 species with the exception of results of surveys of special status species and notes on observations of rare species.

Challenging tasks we faced in implementing analyses were generating a plausible index of abundance that accounted for differences in methods and effort, and developing approaches to assess temporal differences in communities. This latter issue was important given a major gap in sampling that (without SODN data) included a period from 2005 to 2021, unbalanced effort across space, and changes in methods from belts to points in the mid-1990s. To address the first issue, we used total count time in mins to index effort and scale the number of observations of each species to compute relative abundances. Although count time varied from 36-168 mins during surveys of belt transects (mean = 82 mins.) and point counts of 5, 7, 8 and 10 mins were completed across time, effort in time was known. Because distance recording methods also varied widely and surveys of belt transects recorded species and number of individuals detected outside belts, we summed detections of all individuals combined including flyovers and divided by count time in mins to compute an index of relative abundance. For comparisons, we also computed relative abundance based on detections from point counts within 50 and 100 m; variation in distance bands among years precluded estimates within 100 m in 1995, 1996, and 1998, however. To foster temporal comparisons, we considered three discrete time periods rather than performing formal trend analyses (e.g., fitting year as a continuous factor). This approach helped address gaps in sampling and reduced potential biases linked to shifts from belts to point counts because each method was used at least once at each site with four exceptions in the first time period during the 1990s. As time periods, we considered the 1990s based on six years of surveys (1993-1996, 1998-1999), the early 2000s based on five years (2000-2004), and 2021 based on recent surveys. These periods corresponded generally to marked differences in climate in OPCNM that are described below. Importantly, all 19 sites considered were visited at least once in both the first (1990s) and last (2021) time periods, but nine sites were not visited in the middle period (2000-2004; Table 2). During the first period, sites were visited during an average of 2.9 years (range = 1-6) with an average of 3.9 visits within years they were considered (range = 3-6). Because the most recent period in 2021 was based on only a single exceptionally dry year, patterns describe here may not be broadly representative of current conditions.

We used multiple techniques to assess variation in breeding bird communities across time and space. In assessing variation, we considered all breeding species combined, some individual species of interest, and species groups linked to habitat affinities and traits of each species. These groups were derived from information on habitat use and fundamental limiting resources from the literature and our own knowledge. Groups included species associated with desert scrub (e.g., Black-tailed Gnatcatcher, Cactus Wren), cavities in saguaros or occasionally large trees (e.g., Ash-throated Flycatcher, Gila Woodpecker), mountain slopes or cliff faces (e.g., Prairie Falcon, Rufous-crowned Sparrow), exotic species and those often linked to human habitats in the region (e.g., Eurasian Collared-Dove, Red-winged Blackbird), riparian woodlands (e.g., Ferruginous Pygmy-Owl, Bell's Vireo), generalists (e.g., Common Raven), nectar (Costa's Hummingbird), shrub-obligates (Canyon Towhee), seeds (Lesser Goldfinch), and the nest parasite Brown-headed Cowbird. To help assess factors that explained spatiotemporal changes in communities, we evaluated patterns in the habitat affinities of species contributing to observed variation in communities, which helped infer potential drivers of change.

Quantitative Analyses

To assess spatiotemporal variation in communities, we performed nonmetric multidimensional scaling (NMDS) on a Sørensen distance matrix in up to six dimensions and used stress values to select an optimal solution. NMDS is an iterative ordination method that generates a monotonic or “low stress” configuration based on ranked distances among sampling units (Kruskal 1964). Unlike principal component analysis, NMDS does not assume linear relationships among variables, which in our case were species (McCune et al. 2002). Sørensen distances were used because they provide a biologically intuitive fixed maximum distance for sampling units with no species in common. The community matrix included estimates of relative abundance for all 53 regularly occurring breeding bird species (columns) at each site surveyed ≥ 3 times within a year (rows). Although the design was unbalanced, this approach fostered inferences to all sites including those visited rarely across time, many of which were of interest given they were along the U.S.-Mexico border. Focusing analyses on just these 53 bird species removed rare species and reduced noise that can be introduced by species that do not typically breed. Relative abundance of each species was computed as the mean number of individuals observed at all distances from observers per minute of effort among all visits to a site within a year. We square root transformed estimates to reduce the influence of extreme values before computing Sørensen distances. This procedure is similar to log transformation but does not require special treatment of zeros or yield negative values.

We used several approaches to assess patterns of temporal variation in communities across time. First, to test for overall differences in communities among time periods, we used multi-response permutation procedures (MRPP; Mielke 1984). MRPP provides quantitative measures of the effects of spatial and/or temporal groups in nonparametric data and is similar to permutation multivariate analysis of variance (PerMANOVA) but based on average within-group distances and asymptotic evaluations of P -values. Due to the unbalanced design, we could not use PerMANOVA or blocked MRBP to test for within-site difference across time periods, and hence time period was the single focal factor in MRBP. Second, we identified species and species traits indicative of each time period with the use of blocked indicator species analysis (bISA; Dufrêne & Legendre 1997). This approach utilizes proportional species abundances and frequencies to compare observations among sites (blocks) and computes indicator values (IV) between 0 and 1 to quantify associations between each species and time period, with P -values based on random permutations. Such IV reflect the strength of association between species and time periods based on concentration of abundance and faithfulness within periods, and can suggest deterministic changes in communities across time or space, or potentially differences in detection probabilities. Third, we compared period-specific occurrence probabilities for each species by dividing the number of site years each species was detected by total site years within each time period. Although not adjusted for detection probabilities, each site year of observations included a minimum of three visits to all points along transects during which even species with low detection probabilities were likely to be observed. We then graphically compared probabilities for species and species groups linked to habitat affinities focusing on the first and last periods when all 19 sites were visited. Finally, we fit vectors for time since the start of the study (1993), and time period to ordination results to assess associations (see below).

To assess how variation in the environment was associated with spatiotemporal variation in bird communities, we fit vectors onto ordination plots and computed Pearson correlation coefficients between vectors and ordination axes. As environmental factors, we considered the various geographic, landscape, temporal, vegetation, and climatic factors, and categorical estimates of anthropogenic disturbance linked to border development described above. These vectors pointed in directions factors varied most in ordination space and had lengths scaled to the magnitude of correlation.

Because variation in methods and protocols across time required assumptions linked to relative abundance calculations, we quantified how ordination results varied among different datasets to confirm our approach, and assessed relationships between ordination scores and field method. This involved using Mantel’s asymptotic approximation method (Mantel 1967) to compare ordinations based on the primary

dataset that was based on computations of relative abundance from observations at unlimited distances during point counts, with those from datasets based on relative abundances estimated only with detections from within 50 m of points and on presence/absence data for each species. The standardized Mantel statistic (r) ranges from 0 to 1, with 1 indicating perfect correspondence between two ordinations and has a null hypothesis of no relationship between matrices. Comparison with ordinations that used relative abundance estimates based on observations at other distances was not possible because variation in methods across time produced different sample sizes. We also fit a vector for method (belt vs. point counts) to assess its relationship with spatiotemporal variation in bird communities. We implemented NMDS, MRBP, bISA, and Mantel tests with PC-ORD V.6.0 (McCune & Mefford 2011).

To provide additional context for understanding bird community and habitat change, we assessed trends in cover of creosote bush and leguminous trees between 1995 and 2009. We fit linear mixed effects models with year fit as a fixed trend term, station and transect fit as random intercepts, and log-transformed cover estimates within 150 m of each point, which we fit as response variables. To assess differences in trends across the landscape, we computed trends for all points combined and subsets of points within each of the three landforms (e.g., valley bottom, bajada, rockslope-canyon), vegetation formation, and hydrologic types. Models were fit with the lme4 library in R (R Core Team 2021).

RESULTS

Between February and May 2021, we spent portions 118 days completing various field and outreach activities in OPCNM and Pinacate (Table 4). Effort was much greater in OPCNM given the presence of a large number of monitoring sites and our objectives. Below we provide an overview of efforts and results from each reserve.

Pinacate Biosphere Reserve

Outreach and Education: We presented a talk on bird ecology and distribution in Pinacate for CEDO, reserve staff, collaborators, and members of the community in February 2021. This event was hosted by CONANP and held in their modern theater facility at the reserve visitor centers and attended by ~20 participants (Table 4, Appendix A). This activity was followed by a presentation and discussion on proposed field methods, point count procedures, study design considerations, analysis linked to bird monitoring, and past efforts in OPCNM. Following these presentations indoors, we spent the next three days demonstrating field methods to CEDO biologists and collaborators in the field on the reserve and training them in bird identification and implementation of field methods. All presentations and activities were well received by participants and prepared CEDO biologist Ángeles Yazmín Sánchez Cruz and others to assist with bird surveys in Pinacate. Ángeles and associates also attended follow-up efforts hosted by Miguel Grajeda in April 2021. Other results of our education and outreach efforts in Mexico included an article we published in CEDO's online newsletter on the project and importance of bird monitoring entitled *Monitoring the pulse of the desert through avian monitoring in the Pinacate Biosphere Reserve* (Appendix C). Retired U.S. Fish and Wildlife Service biologist and CEDO volunteer Mark Kaib wrote an article for the newsletter on his experiences working with CEDO and UA project staff entitled *A letter from a CEDO friend* (Appendix D).

Surveys of Special Status Species: Over portions of four days in Pinacate, we surveyed numerous localities for raptors, cliff-nesting, and other special status birds. These efforts targeted Golden Eagle but also revealed other species of interest. Efforts focused on five cinder cones, areas around and mainly north of the high peaks of the Pinacate range, and on six craters of various sizes throughout the reserve (Tables 5 and 6). A total of 11.9 and 11.3 hrs of constant-effort observations were made from fixed observation posts at craters, and at cinder cones including in the high peaks area, respectively, and 12 target species were detected (Table 5 and 6). Importantly, these efforts confirmed the continued presence

of the Golden Eagle in Pinacate; one sub-adult was observed for over an hr around a large crater on 25 March 2021, another probable individual was seen a long distance away (~2 km) in the high peaks area on 20 Feb. 2021, and a possible used nest was observed on the north side of a large cinder cone on 24 March 2021, but no individuals were seen here (Table 5 and 6). Other notable observations included two Prairie Falcon territories at large craters including one occupied nest, and another individual in the high peaks area. Red-tailed Hawk was by far the most common raptor we detected. Locations of sites we surveyed are available by request and are not provided here to protect sensitive locality information.

Bird Monitoring: In 2021, project partners surveyed each of 10 transects 1-2 times during the breeding season (Figure 2). This effort resulted in 618 bird detections totaling 834 individuals of 60 species. In general, encounter rates were very low in Pinacate due to limited densities of birds in these hyperarid environments. Issues with availability of our Mexican collaborators precluded some planned visits to some transects and hence we did not obtain the desired three visits per transect. Comparing results obtained during bird surveys during 2021 with previous years of data obtained by Miguel Grajeda and CONANP, species richness was higher in 2021 than in prior years due likely to increased effort and coverage. Across all years, a total of 84 bird species have been observed during point counts in Pinacate. Miguel Grajeda provided a detailed description of study sites, differences in observed species richness across time, and lists of species and total detections during each year of effort including 2015-2017, which is provided in Appendix E. The final data product from 2021 was shared with all project partners. Data from earlier years was not shared with NPS or the PI precluding additional analyses.

Organ Pipe Cactus National Monument

Notable Observations: We recorded several notable bird species and observations in OPCNM during 2021 that are described here to augment information on the status and distribution of birds in the monument. The most noteworthy was an observation of a single calling Nutting's Flycatcher (*Myiarchus nuttingi*) that is described in detail below to provide documentation for consideration by the Arizona Bird Committee. A single individual of this species was detected at point seven in Alamo Canyon in the Ajo Mountains at 7:39 AM on 18 May 2021 by A. D. Flesch. This individual was initially heard calling two times with the typical loud "wheeeep" call before being seen and studied for several minutes at distances of ~15-30 m with Leica 10 x 25 BCA binoculars in excellent lighting. Having observed this species hundreds of times in neighboring Sonora, Mexico and being very familiar with its vocalizations, the bird was recognized as a Nutting's Flycatcher after the second vocalization. Many common field marks were also corroborated visually including: 1) bright yellow coloring on the belly that is much more luminous than that found on Ash-throated Flycatcher, 2) distinct brown coloring on the crown, upper back, and face that had little grayish hues as is found on Ash-throated Flycatcher, 3) orange- to yellow-lined edges on the outer to inner secondary feathers on the folded wing, and 4) rufous-colored inner tail feathers on the underside of the tail that extended to the base. The bird was detected at an elevation of 753 m along the mesquite- and scrub-oak-lined wash along the canyon bottom with dense thornscrub-like shrubland and grassy openings on adjacent slopes. Based on field marks and the unmistakable booming call, which is unlike any given by Ash-throated Flycatcher, I have no doubt this bird was in fact a Nutting's Flycatcher. Danny Martin attempted to relocate the individual the following morning on 19 May 2021 but did not detect it. Peter Holm made a follow-up visit on 23 May and also did not detect the bird but observed 26 other bird species.

Other notable observations of birds were obtained both during and after point counts. Two Black-chinned Sparrows were singing on shrub-dominated hillsides above Bull Pasture at an elevation of ~980 m on 29 April, but were not detected on a subsequent visit on 20 May suggesting they did not stay to breed. A single Bendire's Thrasher was singing in open desertscrub from a hillside north of Pozo Nuevo Well on 5 March at an elevation of 385 m, not detected on a second visit on 14 April, but heard singing nearby on the last visit on 14 May. A pair of Blue-gray Gnatcatchers were interacting in oak woodland in Alamo Canyon at an elevation of 780 m on 18 May and one was building a nest in a scrub-oak (Appendix A).

Another singing Blue-gray Gnatcatcher was also detected above Bull pasture at an elevation of 1075 m in woodland dominated by Arizona rosewood, but not detected on 20 May. A pair of Crested Caracaras was observed along the border at Burn Site on 3 March and a single was at Dos Lomitas on 7 April. A single Sage Thrasher was observed in open desert scrub in Growler Valley on 4 March. We obtained a total of 10 records of Pine Siskin of between one and nine individuals at eight different sites across OPCNM, with all observations between 11 and 27 May. Finally, a single Brown Pelican was observed around the pond at Quitobaquito on 5 April.

Surveys of Special Status Species: Surveys for Golden Eagle were somewhat limited due to other priorities and lack of spatial overlap between suitable eagle survey areas and point transects. Nonetheless, we spent portions of two days at constant-effort observation posts surveying for eagles, one in the Bates Mountains and another above Bull Pasture in the Ajo Mountains. During four hrs of effort in view of some of the tallest cliffs in the Bates Mountains on 3 March, we observed a single Golden Eagle circling a peak for approximately 30 sec before it flew south out of view along the ridge top. During 2.2 hrs of effort within view of the top and great west walls of the Ajo Mountains on 20 May, we failed to detect eagles nor did we detect them during any point count efforts in the Ajo mountains along the Alamo Canyon or Bull Pasture transects.

We made much greater efforts to survey for Ferruginous Pygmy-Owls. This work included surveys of 45 stations and 360 mins of effort at various sites that we targeted across OPCNM (Table 7). We surveyed within ~400-500 m of most past locations where pygmy-owls had been detected in OPCNM with the exception of the following: 1) near the visitor center, 2) some single isolated localities at Dripping Springs, Bonita Well, and east of Montezuma Head, 3) areas along lower Alamo Wash, and 4) several widely-spaced localities near State Route 85 in the vicinity of East Armenta Road and lower Kuakatch Wash, where there are several highly dispersed historical records. On the morning of 30 April, A. D. Flesch detected a territorial male Ferruginous Pygmy-Owl at 6:17 AM at a distance of ~60 m. The bird called without solicitation during a point count. This same individual was heard at the next two points at distances as far as ~600 m away and called on and off for nearly an hr. Based on the persistence of calling, vocalization type, and coloration of the tail and back, this bird was an unpaired male. This same owl responded to a single short bout of recorded territorial male calls in the same area ~3 hrs later but no other pygmy-owls were detected along this transect during other surveys that day. On 25 May at 7:33 AM on the next point-count survey, Peter Holm detected what was likely the same individual ~200 m upstream from the initial 30 April location. The owl was heard calling for ~1 hr without solicitation and hence was likely unpaired. On the same date ~1.5-2 km downstream to the west, Danny Martin detected another pygmy-owl that based on vocal and plumage traits was a territorial female and likely unpaired. A social media post by OPCNM about these observations garnered 250 likes and 32 shares on Facebook (Appendix F). Danny Martin completed additional surveys of pygmy-owls in OPCNM in 2021, but to my knowledge, no other individuals were detected. Sites where we observed pygmy-owls are not provided to protect sensitive locality information.

Bird Monitoring Effort - 2021: With major help from Peter Holm and UA technician Fernando Diaz, we completed surveys of all 25 point transects three times between late Feb. and late May 2021. Effort spanned 196 points and resulted in 6,382 bird detections totaling 7,722 individuals of 107 species, which includes before- and after-count detections (Table 4). A total of 90 detections and 106 individuals were not identified to the species level but included in the database. Table 8 summarizes all species observed during point counts, number of observations and individuals, mean detection distance, and frequency of occurrence across the 25 transects by species, which includes the six SODN transects. The draft final 2021 data product was provided to Peter Holm in Fall 2021. It noted some small issues that needed to be addressed for counts completed by NPS staff before finalization and incorporated into NPS data files.

Bird Communities 1993-2021: The final data product included information from 126 site years and 427 site visits across nearly a 30-year period. Of that effort, 19 site years and 57 site visits were from 2021.

Effort during OPCNM's EMP work from 1998-2004 accounted for most site years of effort (52%), with less effort during initial belt transect surveys efforts (21%), UA-NPS efforts in 2021 (15%) and Kern River Science Center work in 1995-1996 (13%). Because no data were obtained for SODN work in 2007-2015, we censored estimates from 18 site visits to these six transects in 2021. Since 1993, a remarkable total of 62,429 individual bird detections of the 53 focal breeding species were considered.

Species composition of bird communities at the 19 long-term study sites varied among the three time periods ($A = 0.086$, $P \leq 0.001$; MRPP). Average distance among communities at sites surveyed in the 1990s was highest (0.38) overall but also included more site years of data (59) and was based on surveys of both belt transects and point count. Average distances were slightly lower in 2021 (0.35) and lowest in the early 2000s (0.33), but nine sites were not surveyed during this period despite all observations being based on point counts. Pairwise comparison from MRPP indicated significant differences in communities between all three possible combinations of time periods ($A \geq 0.040$, $P \leq 0.001$), suggesting important temporal shifts in species composition.

NMDS ordination of bird species' relative abundances at sites across time summarized relationships between species composition, environmental variation, and differences across the three focal time periods (Figure 3). NMDS projected the distance matrix into three-dimensional space with fairly low stress (0.118, final instability = 0.0000) and produced a cumulative R^2 of 0.90. Axis 1 explained 40.9% of the variation in the bird community matrix, axis 2 explained another 32.5% of variation, whereas axis 3 explained 16.1%.

Temporal shifts in bird community composition were characterized by decreasing values along the third ordination axis (top row Figure 3), and time measured in years since 1993 was moderately negatively correlated with axis 3 (Table 9; bottom row Figure 3). Communities in 2021 were intermediately positioned between those in the 1990s and early 2000s, especially when viewed along the 1st and 3rd axes. The Growler Valley site, which is among the most arid and likely the most extreme site we considered in OPCNM (and was surveyed in all three time periods), provided an informative reference point for understanding temporal variation in communities. This site was positioned in its own region of community space and had high negative values along axis 3 (middle row Figure 3, middle and right), which was most strongly correlated with increasing time. Centroids and convex hulls representing communities in 2021 showed distinct shifts in the direction of ordination space occupied by Growler Valley (top row Figure 3, middle and right). Importantly, spatiotemporal variation in annual P and tree cover were also moderately to strongly correlated (e.g., $r = 0.55$ - 0.64) with ordination results in directions mainly opposite that of increasing time and communities at the Growler Valley site. Hence, vectors for annual P and tree cover pointed in directions of community space typical of the 1990s (Table 9, Figure 3, middle and right). With regard to species, two non-native species (Eurasian Collared-Dove, European Starling) were positioned in areas of community space associated with more recent times, as were many species that use open country. In contrast, two woodland species (Bell's Vireo, Rufous-winged Sparrow), the nest parasite Brown-headed Cowbird, and seed-dependent Lesser Goldfinch were positioned in the opposite direction and hence associated with earlier time periods.

Most sites occupied fairly unique areas of bird community space and spatial variation among sites was linked to apparent environmental drivers. Sites with lower values along axis 2 (e.g., Cuerda de Leña, Growler Canyon, Kuakatch) tended to be in valley bottoms, riparian areas, and dominated by woodland vegetation (middle row Figure 3, left). Hence axis 2 was highly negatively correlated with ranked orders of all three general environmental categories that described landforms, hydrology, and vegetation formations (Table 9), and woodland-dependent species tended to have low values along axis 2 whereas species linked to cliffs and mountain slopes tended to have high values (bottom row Figure 3). Similarly, sites with higher values along axis 2 (e.g., Diablo Mountain, Bull Pasture) tended to be at higher elevations, and hence axis 2 was positively correlated with T of the coldest month (Table 9). Sites with higher values along axis 1 were often near the international border and had greater impacts of border-

related disturbance. Vectors representing border-related disturbance were nearly parallel to and moderately positively correlated with axis 1. Moreover, species with habitat affinities linked to human settlements, agriculture, and exotics, such as Great-tailed Grackle and Red-winged Blackbird, which tend to occur in developed areas in the adjacent Sonoyta Valley, had the greatest values along axis 1. In general, sites dominated by desertscrub or narrow stringers of riparian trees and that are on bajadas were positioned near the center of ordination space, with species linked to desertscrub and saguaro cavities positioned similarly.

Weather and vegetation factors were also correlated with spatiotemporal variation in bird communities. Overall, P was more strongly correlated with ordination results than T (Table 9). Among factors that described P , annual P was much more highly correlated with ordination results than seasonal estimates in both the warm or cool seasons, and magnitudes of correlation generally increased with broader moving averages of annual P (Table 9). Seed-dependent Lesser Goldfinch occurred in an area of community space toward which vectors representing P pointed, especially annual P during the past year compared to P measured more broadly. Among vegetation factors, spatiotemporal variation in tree cover was most strongly correlated with variation in bird communities, and relationships were much weaker with creosote bush and especially all woody cover combined. When vegetation factors were computed on a percent change scale across time to provide a purely temporal signal, relationships were weak.

Various species and species' habitat affinities were linked to different time periods, and these patterns described important shifts in bird communities. Based on bISA, five bird species dependent on woodlands or dense shrubs including Bell's Vireo and Rufous-winged Sparrow were indicative of historical communities in either the 1990s or early 2000s, with the exception of Lucy's Warbler that was indicative of recent communities (Table 10). In contrast, six species of cavity nesters that were mainly woodpeckers and *Myiarchus* flycatchers were indicative of recent communities. Similarly, hummingbirds associated with nectar and non-native Eurasian Collared-Dove were indicative of recent communities, whereas parasitic Brown-headed Cowbird was indicative of communities in the 1990s. Importantly, comparison of period-specific occurrence probabilities of each bird species indicated that a similar numbers of species had higher occurrence probabilities during the 1990s (20) as in 2021 (27), with seven species with essentially equal probabilities across time (Figure 4). In general, species with higher occurrence probabilities in the 1990s tended to be associated with woodlands and dense shrubs, whereas those with higher occurrence probabilities in 2021 tended to be associated with open country, cavities, or nectar (Figure 4). Eurasian Collared-Dove was the only species not observed historically that was observed in 2021. In contrast, Harris' Hawk, Zone-tailed Hawk, and Rufous-winged Sparrow, which are essentially woodland species, and Purple Martin and Great-tailed Grackle, were the only species observed historically but not in 2021. Period-specific differences in occurrence probabilities were highest for Brown-headed Cowbird, which was observed during 92% of site years in the 1990s but only 42% in 2021. Woodland-dependent Bell's Vireo and Hooded Oriole has occurrence probabilities that were 30-40% higher in the 1990s.

Finally, we compared NMDS scores to test whether assumptions linked to relative abundance calculations or substituting data on presence/absence (vs. relative abundance) influenced results. Mantel tests comparing alternate NMDS scores found strong redundancy among ordinations. The standardized Mantel statistic comparing ordinations that only used bird observations within 50 m of points to compute relative abundance and for presence/absence equaled 0.76 and 0.72, respectively, indicating fairly strong redundancy among ordinations. The configuration derived from computing average relative abundance across all distances we used also had the lowest final stress (0.118) compared to other configurations (0.125-0.163), and equal or higher R^2 (0.81-0.90) also justifying our approach. Ordination results, however, were highly associated with differences between the two field methods and this variation was largely addressed by axis 1 that was uncorrelated with time (Table 9, Figure 3).

Environmental Change: Changes in vegetation cover within 150 m of point count stations between 1995 and 2009 showed some important temporal trends that varied spatially. Across all points combined, leguminous tree cover declined by an average of $1.0 \pm 0.1\%$ per year but there were no trends in cover of creosote bush (Table 11, Figure 5). Trends in leguminous tree and creosote cover varied widely among different hydrologic types and landforms ($P \leq 0.03$; ANOVA) but less so among vegetation types. Declines in tree cover were greatest around points in mixed hydrologic types and lower in upland and riparian contexts, and also greater in mixed and shrubland vegetation types compared to in woodlands where cover also declined but at lower rates (Table 11, Figure 6). Trends in cover of creosote bush were generally more variable across time. Creosote cover was stable in riparian areas, woodlands, and valley bottom, increased in mixed hydrologic types and on bajadas, and declined most on rockslopes and in canyons where soils are typically shallowest (Table 11, Figure 6).

Climate varied markedly among the three time periods we used as design variables to assess temporal variation in bird communities. Years during which we had bird data in the 1990s, for example, were relatively wet and cool with annual P that averaged ($\pm$ standard error) 10.1 ± 0.3 in. and MAT that averaged $21.5 \pm 0.1^\circ \text{C}$. In contrast, the period in the early 2000s averaged drier (7.5 ± 0.4 in.) and also slightly warmer ($21.8 \pm 0.1^\circ \text{C}$), whereas the most recent period in 2021 was even drier (4.6 ± 0.8 in.) and almost 1-deg. C warmer ($22.6 \pm 0.2^\circ \text{C}$), with all contrasts being highly statistically significant ($P < 0.0001$, ANOVA).

DISCUSSION

We addressed a broad suite of objectives focused on bird monitoring in Organ Pipe Cactus National Monument (OPCNM) in 2021 and on applying an extensive set of past data on birds to assess changes in bird communities across nearly three decades. We also helped link bird monitoring in OPCNM with similar efforts in the adjacent Pinacate Biosphere Reserve in Mexico, train park staff and cooperators in the U.S. and Mexico in field methods, and provide education and outreach to local human populations in the borderlands of Mexico. Efforts to monitor birds in OPCNM during this project were the first in 16 years to visit a large set of long-term monitoring sites that were established by NPS and their collaborators in the late 1980s or 1990s. Our efforts also provided the first comprehensive analyses of temporal changes in breeding bird communities across the entire monument, which is noteworthy. Numerous past methodological changes, sporadic past visitation schedules, and our inability to acquire important data from collaborators and other NPS entities challenged our efforts, but nonetheless we obtained some important inferences. Although more work remains and numerous future avenues discussed below can advance efforts further, we found evidence of a broad range of highly relevant patterns including some that are auspicious and some that are discouraging from conservation and management perspectives.

Community Variation and Change in Organ Pipe Cactus National Monument

Multivariate techniques provided both ecologically and spatially coherent results, and some novel insights into environmental factors associated with spatiotemporal variation in bird communities in OPCNM since 1993. Each long-term study site in OPCNM occupied a fairly unique area of bird community space and spatial variation among sites was linked to ecological gradients in landforms, vegetation, and elevation, but only with some climatic factors. Ordination also effectively organized bird species in environmental space in ways that corresponded to differences in species' habitat affinities, especially for species linked to riparian woodlands and to cliffs and mountain slopes. Interestingly, variation in bird communities was much more strongly associated with precipitation (P) than with temperature (T) factors, with the exception of T of the coldest month that was likely an artifact of elevation. Such results are surprising given broad ecological relevance and importance of both P and T in driving reproductive, population, and community responses of birds and other wildlife in aridlands (Wolf, 2000, Stenseth et al., 2002,

Holmgren et al. 2006, Flesch et al. 2015, McCreedy and van Riper 2015). With regard to the influence of P , associations were strongest for annual versus seasonal estimates of P . Moreover, annual P measured by broader moving averages across time (e.g., from 2- to 5-year averages) was increasingly associated with variation in bird communities suggesting its effects were linked to broad changes in climate rather than specific weather events such as wet or dry years. More effort to parse the relative influence of spatial versus temporal variation in P across time will help better elucidate these patterns and the likely impacts of various climate change scenarios in this region of the Sonoran Desert. Finally, although an index of border-related disturbance was also associated with variation in bird communities, such patterns were likely due more to similarities in environments and hence bird communities among sites near the border than to the effects of recent border development, which have been extensive (Peters et al. 2018). Future work and more focused comparisons can build upon these findings once quantitative estimates of border-related and other human impacts have been measured by NPS and project collaborators.

With regard to vegetation, spatiotemporal variation in tree cover was much more strongly correlated with variation in bird communities than cover of creosote bush. This pattern was likely due to overarching influences of tree cover on the amount and quality of habitats, thermal cover, protection from predators, and foraging space provided by desert trees such as mesquite for various species of birds (Lloyd et al. 1998, Flesch et al. 2015). However, we also found that temporal variation in tree cover had much lower associations with variation in bird communities but nonetheless in the expected direction based on temporal shifts (see below). Both spatiotemporal and temporal patterns for vegetation, however, were likely dampened by the fact that data on tree cover we obtained extended only to 2009 and may not have adequately described environments occupied by bird communities that we sampled in 2021. Importantly, tree cover generally declined across time especially in more moisture-limited contexts like those on shallower soils matching recent findings (Munson et al. 2016). The degree to which these temporal changes influence bird communities will require additional analyses and more up-to-date measurements of tree cover.

Multivariate techniques such as those used here can provide important insights into temporal changes in bird communities and factors that drive them (Curtis et al. 2015, Flesch 2018a). In general, patterns of community change in OPCNM suggest a community that has shifted over time in a direction consistent with increasing aridification. Such shifts are expected due to climate change and have been observed in other nearby aridlands (Iknayan and Beissinger 2018, Riddell et al. 2021, Roberts et al. 2021). Evidence of these patterns in OPCNM is notable given minimal changes in land use and land cover in this protected area aside from those immediately along the U.S.-Mexican border. Such shifts were evidenced by ordination results that showed changes in community composition in a direction toward the harshest and most arid site we considered—Growler Valley. OPCNM is situated in a broad transition zone where open desert woodlands of the more mesic Arizona Upland subdivision of the Sonoran Desert are replaced by more xeromorphic shrub-dominated desertscrub of the Lower Colorado River Valley subdivision due to decreasing elevation and increasing aridity. Growler Valley in the northwest portion of OPCNM is indicative of Lower Colorado River Desertscrub where bird populations generally have lower densities and communities are less diverse due to resource scarcity, limited vegetation cover, and environmental harshness (Hensley 1954), which make these observations important from a conservation perspective. Not surprisingly, these spatiotemporal shifts in communities were associated with lower rainfall and lower tree cover that are important drivers of community composition. Similarly, bird species with affinities to woodlands and dense shrubs typical of riparian areas such as Bell's Vireo were indicative of historical communities and had lower occurrence probabilities in 2021 compared to those observed in the early 2000s and especially the 1990s. In contrast, the opposite pattern was apparent for species that use open country and for generalists such as Common Raven, which is also consistent with increasing aridification (Iknayan and Beissinger 2018). Such patterns mirror recent results for lizards in OPCNM where species traits that influence vulnerability to a changing climate had major effects on variation in population trends among a less diverse community (Flesch et al. 2017). Because 2020 and early 2021 was a period of extreme drought in the northern Sonoran Desert region and because we only had a single year of recent

bird data to foster comparisons, we are unsure if these patterns are broadly representative of current times or an outlier. One or more years of future bird community sampling combined with more refined and up-to-date environmental measurements and additional analytical tools such as occupancy and abundance modeling can help elucidate the magnitude and generality of these patterns in the future.

Temporal changes in bird communities we observed in OPCNM were much less extreme than those described recently in the adjacent Mohave Desert. In the Mohave, recent work found evidence of widespread collapse of breeding bird communities based on data from a longer temporal frame that began between the early 1900s and late 1960s (Iknayan and Beissinger 2018). In the case of Mohave Desert bird communities, declines in occupancy probabilities were statistically significant for 39 of 125 species and >90% of species had point estimates of occupancy probability from the historical period that were lower than recent estimates (Iknayan and Beissinger 2018). Instead, we found that observed period-specific estimates of occurrence probabilities in OPCNM were much more auspicious and showed similar numbers of species with higher occurrence probabilities during the 1990s and 2021, indicating much greater stability (e.g., compare Figure 4 with Figure 1 in Iknayan and Beissinger 2018). Hence, although evidence of community shifts driven by apparent climate change are present in OPCNM, they are less severe due likely to a less extreme environment, more limited environmental changes, or perhaps the shorter time period we considered here.

Despite evidence of increasing aridification in OPCNM, some other community changes we observed were more auspicious. Occurrence probabilities of the nest parasite Brown-headed Cowbird, for example, declined in each of the two most recent time periods and was indicative of the 1990s period when it was widespread and observed during >90% of site years. In 2021, however, we observed Brown-headed Cowbird at only 42% of sites suggesting it has declined markedly in the monument. Because this species can have major impacts on populations of some species songbirds and is of widespread concern (Morrison et al. 1997), such changes in OPCNM are likely beneficial to avian communities. Interestingly, we also found evidence that cavity nesters such as woodpeckers and the two *Myiarchus* flycatchers that breed in OPCNM were indicative of recent communities in 2021 and generally had higher recent occurrence probabilities. Such patterns are curious and may have been driven by increases in the density of cavities in saguaros, differences in observers between time periods, or greater detection probability linked to recent loss of tall tree cover. Similarly, high indicator values and greater recent occurrence probabilities of two breeding hummingbirds are also curious and likely related to an exceptional ocotillo bloom in 2021 (Peter Holm, *pers. comm.*). In the case of the Anna's Hummingbird, this species has been expanding its range in the region in recent decades but could also be due to differences among observers.

Pinacate Biosphere Reserve

With major help from Miguel Grajeda, CEDO, and CONANP, we began important work to re-implement bird monitoring in Pinacate and connect efforts across the border with those its sister park. Perhaps the greatest accomplishments of this work were: 1) standardizing methods used in each reserve so that data are comparable, 2) training local biologists in the application of point counts and bird identification, 3) expanding the spatial scope of monitoring in Pinacate, and 4) establishing important relationships with partners that will persist beyond the life of this project. Despite these accomplishments, several challenges reduced the effectiveness of our efforts and should be addressed in the future. First, due largely to the hyperarid context, bird densities are remarkably low in many areas of Pinacate. Hence, encounter rates and the sample sizes we obtained per unit effort were among the lowest we have seen anywhere in North America. Given this issue, major effort will be required to obtain sufficient data to foster robust comparisons of communities across time and space. Adding to this challenge, issues with the pandemic and other obligations of our collaborators linked to their doctoral studies reduced effort in 2021 typically to only two visits per transects. Regardless, work we did was significant and involved as much or more effort in Pinacate as has been spent in past years.

Among the more gratifying activities of this project was establishing binational relationships with partners in Mexico. This work involved workshops and educational events in Pinacate that CEDO galvanized excellent participation for and camping with new friends we made during the project in the field. Again, issues with the pandemic and other obligations precluded completion of an educational pamphlet on birds that CEDO began and presented an incomplete draft of during the final days of the project period. Despite incompleteness of these materials, following the project CEDO garnered support from CONABIO (La Comisión Nacional para el Conocimiento y Uso de la Biodiversidad) in Mexico City to further develop these materials and has made excellent progress with help from project staff. If supported in the future, we will continue this work and facilitate the printing and distribution of these educational materials to focal populations in the areas around Pinacate in 2022 and 2023.

Special Status Species and Other Findings

Perhaps the most valuable bird observation we made during the 2021 field season was the first detection of a Ferruginous Pygmy-Owl in OPCNM since late winter 2015 (Hough 2015). This included detection of an unpaired male in April and May in the same general areas, which was accompanied by a record of an additional individual detected by Danny Martin that was likely a female. This bird was not detected by UA staff during two prior surveys to the area in March and April despite call broadcast surveys, suggesting it likely arrived recently. Although the Arizona Game and Fish Department surveyed for the Ferruginous Pygmy-Owl in recent years in OPCNM, including in 2020 and 2021 (Danny Martin, *pers. comm.*), they failed to detect pygmy-owls likely because they did not survey the highest quality habitat in the monument. This habitat is also best connected to habitat and source populations of owls on the adjacent Tohono O’odham Nation. Annual fluctuations in population sizes and reproductive output of Ferruginous Pygmy-Owls are highly impacted by drought such that areas that provide habitat likely become largely unsuitable after sets of dry years (Flesch 2014, Flesch et al. 2015). These patterns and the fact that OPCNM is located at the far western and hence most arid portion of the species’ range suggests population sizes are highly dynamic in the monument, which is supported by past survey results by NPS. Habitat connectivity has major impacts on distributional dynamics of pygmy-owl populations (Flesch 2017). Hence, more distant and isolated habitat like that in Growler Canyon is less likely to be occupied than habitat to the east closer to source populations on the Tohono O’odham Nation, especially after dry years. Patterns of occupancy we observed in 2021 matched these general expectations. Despite 2021 surveys of a large number of past locations where pygmy-owls had been detected in OPCNM since the 1970s, we failed to locate any additional individuals. With the exception of large tall woodlands, the vast majority of these historical localities are not likely to be occupied except following multiple wet years. We suspect analyses of rainfall quantities in years prior to the timing of many past historical observations will confirm this expectation.

Another highly significant observation from 2021 was presence of a Nutting’s Flycatcher in Alamo Canyon in mid-May. Vegetation in the canyon is more open than that typically used by this species in neighboring Sonora, but has some resemblance to areas occupied in northern Mexico. If accepted by the Arizona Bird Committee this would likely be just the 8th record of this species and perhaps the 4th general locality in Arizona (Felipe Guerrero, *pers. comm.*, Rosenberg et al. 2019). Some literature, however, indicates this may not be the first observation of Nutting’s Flycatcher in OPCNM. This species was on the list of Benson et al. (2001) who implemented mist netting in OPCNM between 1997 and 2000, potentially also in Alamo Canyon. Although this report was not present in OPCNM files and hence has not been reviewed, it was cited by Schmidt et al. (2007) who included Nutting’s Flycatcher on the list of OPCNM birds.

The Golden Eagle is one of the lesser-known bird species in OPCNM but its status, distribution, and habitat was recently described in the state of Sonora based on over 100 years of observations (Flesch et al. 2020). In OPCNM, the Golden Eagle has been observed in potential breeding habitat near cliff faces in both the Ajo and Bates mountains but records are few and far between during bird sampling efforts. Due

to low natural densities of this species in arid regions of southwestern North America and the infrequency of nesting in drought years (Millsap 1981, Braham et al. 2015), the species may not be detected readily and requires major survey effort to document. Although we can confirm the presence of at least one individual in suitable breeding habitat during the 2021 breeding season in both OPCNM and Pinacate, additional information on status is unavailable. Given the extreme drought conditions in late 2020 and early 2021 this species may not have nested in these reserves during our field efforts.

Conclusions

Understanding the impacts of climate change, anthropogenic disturbance, and other stressors in Sonoran Desert protected areas depends on focused monitoring of natural resources, periodic data assessment, and application of resulting inferences to management and conservation. This effort was the first to report on changes in bird communities based on nearly three decades of survey data from across OPCNM and also helped develop the capacity and set the stage for similar bird monitoring efforts in OPCNM's sister park in Mexico—the Pinacate Biosphere Reserve. In general, we found that bird communities in OPCNM between 1993 and 2021 shifted in ways consistent with increasing aridification and expectations linked to climate change, but not as extremely as shifts observed recently in the Mohave Desert. Temporal shifts in communities were underpinned by losses of species dependent on riparian woodlands and dense shrubs and gains in species dependent on cavities and open-country and generalists, which is consistent with climate-mediated shifts in community composition. Given major temporal gaps in monitoring between 2004 and 2021, and extreme drought prior to recent 2021 surveys, we are unsure whether these patterns are broadly representative of current communities. Additional surveys and more refined environmental measurements will help improve future inferences. Continuing monitoring efforts for wildlife, tree cover, and climate are essential to enhance future inferences. Management and conservation efforts that minimize vegetation and soil disturbance and promote the cover, quality, and connectivity of woodlands in OPCNM will help conserve bird populations for the benefit of future generations.

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Table 1: History of standardized avian sampling in Organ Pipe Cactus National Monument, 1987-2015, detailing number of surveys for each year and study site, field method (belt transect or point count), and investigators. Gaps in effort across time are not always shown (e.g., 1988, 2005, 2006). Cooperative Park Studies Unit (CPSU) refers to effort by Johnson and Hiatt (1992), Kern River Science Center (KRSC) by Halterman and Laymon (2000), and Organ Pipe Cactus National Monument staff (ORPI) with belt transects (OPCNM 1995) and point counts (Tibbitts 2006). Effort by Sonoran Desert Network (SOND) is shown with “x” because we are uncertain of effort across time. Effort for 2021 is shown in Table 2.

[illegible]

KUAK	Kuakatch Wash	ORPI	pt. count							3	3	3	3	3	3				
LOST	Lost Cabin	CPSU, ORPI	belt	1			3												
MIDB1	Middle Bajada 1	ORPI	pt. count							2	3	3	3	3	3	3	3		
MIDB2	Middle Bajada 2	ORPI	pt. count							2	3	3	3	3	3	3	3		
NEOL	Neolloydia Site	CPSU, ORPI	belt	2															
POZO	Pozo Nuevo	CPSU, ORPI	belt			1	1	3	3	3									
QBQT	Quitobaquito	KRSC	pt. count							6	6								
SALS	Salsola Site	CPSU, ORPI	belt	2				3											
SALS	Salsola Site	KRSC	pt. count							6	6								
SENI	Senita Basin	CPSU, ORPI	belt	1	1	1	1	3	3	3									
SENI	Senita Basin	KRSC	pt. count							6	6								
SENI	Senita Basin	ORPI	pt. count									2	3	3	3	3	3	3	1
VULT	Vulture Site	CPSU, ORPI	belt	3	1			3											
R1	Arch Canyon	SODN	pt. count														x	x	x
R2	East Armenta	SODN	pt. count														x	x	x
U1	66 Hills	SODN	pt. count														x	x	x
U4	East Armenta	SODN	pt. count														x	x	x
U5	Middle Bajada	SODN	pt. count														x	x	x
U12	Growler Pass	SODN	pt. count														x	x	x

Table 2: Study sites and years retained for analyses of avian communities in Organ Pipe Cactus National Monument, 1993-2021 noting number of surveys in each year, primary field method (belt transect or point count), and investigators. Gap in effort in 2005-2020 is shown as a single wide column. Cooperative Park Studies Unit (CPSU) refers to effort by Johnson and Hiatt (1992), Kern River Science Center (KRSC) by Halterman and Laymon (2000), Organ Pipe Cactus National Monument staff (ORPI) (OPCNM 1995, Tibbitts 2006), and collaboratively by NPS and University of Arizona (UA) in 2021 (this report). Effort along six Sonoran Desert Network transects is not shown because we were unable to obtain these data and hence include them in analyses, but these transects were sampled three times in 2021.

Site Code	Study Area	Investigator	Protocol	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005...2020	2021
AGUA	Aguajita Wash	CPSU, ORPI	belt	3	3	3											
AGUA	Aguajita Wash	KRSC, ORPI/UA	pt. count			6	6										3
ALAM	Alamo Canyon	CPSU, ORPI	belt	3	3	3											
ALAM	Alamo Canyon	KRSC, ORPI/UA	pt. count			6	6										3
BULL	Bull Pasture	CPSU, ORPI	belt	3													
BULL	Bull Pasture	ORPI, ORPI/UA	pt. count						3	3	3	3	3	3	3		3
BURN	Burn Site	CPSU, ORPI, ORPI/UA	belt	3													3
CUER	Cuerda de Leña	KRSC, ORPI, ORPI/UA	pt. count			6	6		3	3	3	3	3	3	3		3
DIAB	Diablo Canyon	ORPI, ORPI/UA	pt. count							3	3	3	3	3	3		3
DOLO	Dos Lomitas	CPSU, ORPI, ORPI/UA	belt	3	3	3											3
DRIP	Dripping Springs	CPSU, ORPI, ORPI/UA	belt	3													3
EARM	East Armenta	CPSU, ORPI	belt	3	3	3											
EARM	East Armenta	ORPI, ORPI/UA	pt. count							3	3	3	3	3	3		3
GROW	Growler Canyon	CPSU, ORPI	belt	3	3	3											
GROW	Growler Canyon	KRSC, ORPI, ORPI/UA	pt. count			6	6		3	3	3	3	3	3	3		3
GRVA1	Growler Valley 1	ORPI, ORPI/UA	pt. count						3	3	3	3	3	3	3		3
KUAK	Kuakatch Wash	KRSC, ORPI, ORPI/UA	pt. count			6	6			3	3	3	3	3	3		3
MIDB1	Middle Bajada 1	ORPI, ORPI/UA	pt. count						3	3	3	3	3	3	3		3
MIDB2	Middle Bajada 2	ORPI, ORPI/UA	pt. count						3	3	3	3	3	3	3		3
POZO	Pozo Nuevo	CPSU, ORPI, ORPI/UA	belt	3	3	3											3
QBQT	Quitobaquito	KRSC, ORPI/UA	pt. count			6	6										3

SALS	Salsola Site	CPSU, ORPI	belt	3															
SALS	Salsola Site	KRSC, ORPI/UA	pt. count			6	6												3
SENI	Senita Basin	CPSU, ORPI	belt	3	3	3													
SENI	Senita Basin	KRSC, ORPI, ORPI/UA	pt. count			6	6	3	3	3	3	3	3						3
VULT	Vulture Site	CPSU, ORPI, ORPI/UA	belt	3															3

Table 3: Primary terrestrial and diurnal breeding bird species ($n = 53$) in Organ Pipe Cactus National Monument that were the focus of analyses. Other breeding bird species occur in the monument but species listed here are those that regularly occur during the time periods we worked and for which there is evidence of breeding. Species are listed in taxonomic order.

Code	Common Name	Latin Name
GAQU	Gambel's Quail	<i>Callipepla gambelii</i>
EUCD	Eurasian Collared-Dove	<i>Streptopelia decaocto</i>
WWDO	White-winged Dove	<i>Zenaida asiatica</i>
MODO	Mourning Dove	<i>Zenaida macroura</i>
GRRO	Greater Roadrunner	<i>Geococcyx californianus</i>
WTSW	White-throated Swift	<i>Aeronautes saxatalis</i>
ANHU	Anna's Hummingbird	<i>Calypte anna</i>
COHU	Costa's Hummingbird	<i>Calypte costae</i>
TUVU	Turkey Vulture	<i>Cathartes aura</i>
HASH	Harris's Hawk	<i>Parabuteo unicinctus</i>
ZTHA	Zone-tailed Hawk	<i>Buteo albonotatus</i>
RTHA	Red-tailed Hawk	<i>Buteo jamaicensis</i>
FEPO	Ferruginous Pygmy-Owl	<i>Glaucidium brasilianum</i>
GIWO	Gila Woodpecker	<i>Melanerpes uropygialis</i>
LBWO	Ladder-backed Woodpecker	<i>Dryobates scalaris</i>
GIFL	Gilded Flicker	<i>Colaptes chrysoides</i>
AMKE	American Kestrel	<i>Falco sparverius</i>
PRFA	Prairie Falcon	<i>Falco mexicanus</i>
ATFL	Ash-throated Flycatcher	<i>Myiarchus cinerascens</i>
BCFL	Brown-crested Flycatcher	<i>Myiarchus tyrannulus</i>
SAPH	Say's Phoebe	<i>Sayornis saya</i>
VEFL	Vermilion Flycatcher	<i>Pyrocephalus rubinus</i>
LOSH	Loggerhead Shrike	<i>Lanius ludovicianus</i>
BEVI	Bell's Vireo	<i>Vireo bellii</i>
CORA	Common Raven	<i>Corvus corax</i>
VGSW	Violet-green Swallow	<i>Tachycineta thalassina</i>
PUMA	Purple Martin	<i>Progne subis</i>
VERD	Verdin	<i>Auriparus flaviceps</i>
ROWR	Rock Wren	<i>Salpinctes obsoletus</i>
CANW	Canyon Wren	<i>Catherpes mexicanus</i>
CACW	Cactus Wren	<i>Campylorhynchus brunneicapillus</i>
BTGN	Black-tailed Gnatcatcher	<i>Poliophtila melanura</i>
CBTH	Curve-billed Thrasher	<i>Toxostoma curvirostre</i>
BETH	Bendire's Thrasher	<i>Toxostoma bendirei</i>
CRTH	Crissal Thrasher	<i>Toxostoma crissale</i>
NOMO	Northern Mockingbird	<i>Mimus polyglottos</i>
EUST	European Starling	<i>Sturnus vulgaris</i>
PHAI	Phainopepla	<i>Phainopepla nitens</i>
HOSP	House Sparrow	<i>Passer domesticus</i>
HOFI	House Finch	<i>Haemorhous mexicanus</i>

LEGO	Lesser Goldfinch	<i>Spinus psaltria</i>
RWSP	Rufous-winged Sparrow	<i>Peucaea carpalis</i>
BTSP	Black-throated Sparrow	<i>Amphispiza bilineata</i>
CANT	Canyon Towhee	<i>Melospiza fusca</i>
RCSP	Rufous-crowned Sparrow	<i>Aimophila ruficeps</i>
HOOR	Hooded Oriole	<i>Icterus cucullatus</i>
SCOR	Scott's Oriole	<i>Icterus parisorum</i>
RWBL	Red-winged Blackbird	<i>Agelaius phoeniceus</i>
BHCO	Brown-headed Cowbird	<i>Molothrus ater</i>
GTGR	Great-tailed Grackle	<i>Quiscalus mexicanus</i>
LUWA	Lucy's Warbler	<i>Leiothlypis luciae</i>
NOCA	Northern Cardinal	<i>Cardinalis cardinalis</i>
PYRR	Pyrrhuloxia	<i>Cardinalis sinuatus</i>

Table 4: Summary of field activities and effort linked to surveys of birds in Organ Pipe Cactus National Monument (OPCNM) and the Pinacate Biosphere Reserve in Sonora, Mexico during the 2021 field season.

Start Date	End Date	Location	Task	Accomplishments	Effort	Staff
25-Feb	25-Feb	OPCNM	Field training for point counts	Trained 3 NPS biologists to point count birds	1 day	Flesch
3-Mar	20-May	OPCNM	Raptor surveys	Surveyed Bates and Ajo Mountains; 1 eagle detected	2 days	Flesch
9-Mar	21-May	OPCNM	Pygmy-Owl surveys	Surveyed 10 areas; 1 pygmy-owl detected	11 mornings	Flesch, Diaz
25-Feb	27-May	OPCNM	Breeding bird surveys - Point counts	Surveyed 25 transects including 196 points, 3 times: 6,382 detections totaling 7,722 individuals	75 mornings	Flesch, Holm, Diaz
11-Feb	13-April	Pinacate	Field training for point counts	Trained ~8 Mexican field biologists to ID birds and conduct point counts 107 species	4 days	Flesch, Grajeda
11-Feb	12-Feb	Pinacate	Workshop education event	Educational lecture on ecology and management of birds in Pinacate	2 days	Grajeda, Flesch
20-Feb	25-Mar	Pinacate	Raptor surveys	Surveyed High Peaks area, 5 cinder cones and 6 craters throughout Pinacate for raptors, cliff-nesting, and other special status birds	4 days	Flesch
12-Feb	22-Apr	Pinacate	Breeding bird surveys - Point counts	Surveyed 10 transects including 98 points, 1-2 times: 618 detections totaling 834 individuals of 60 species	19 mornings	Grajeda, CEDO, Flesch

Table 5: Results of surveys of raptors and cliff-nesting birds at six craters in the Pinacate Biosphere Reserve in Sonora Mexico in Feb. and March 2021. Locations are available by request from the author and are not provided here to protect sensitive locality information. Abbreviations are as follows: A-adult, M-migrant, N-likely nest, ON-occupied nest, P-pair, sA-subadult.

Species	Large Crater 1		Large Crater 2		Large Crater 3		Large Crater 4		Small Crater 1		Small Crater 2	
	No.	Status	No.	Status	No.	Status	No.	Status	No.	Status	No.	Status
White-throated Swift	6	N	15	N	5	N	10	N				
Black Vulture			1									
Turkey Vulture			12		2		18				1	
Osprey			1	M								
Golden Eagle			1	sA								
Red-tailed Hawk	1	A					1P + 1	A + sA	1			
Great Horned Owl									1P			
American Kestrel			1									
Prairie Falcon			1P	ON			1	T, N				
Say's Phoebe			1									
Common Raven	1P	ON	1P		1P		1P		1		1P	
Effort												
Dates	3/23/2021		3/25/2021		3/24/2021		2/21/2021		3/23/2021		3/24/2021	
Total time (hr:min)	0:50		3:50		1:05		5:20		0:20		0:30	

Table 6: Results of surveys of raptors and cliff-nesting birds at five cinder cones and the high peaks region in the Pinacate Biosphere Reserve in Sonora Mexico in Feb. and March 2021. Locations are available by request from the author and are not provided here to protect sensitive locality information. Abbreviations are as follows: A-adult, M-migrant, N-likely nest, ON-occupied nest, P-pair, UN-used nest.

	Cinder Cone 1		Cinder Cone 2		Cinder Cone 3		Cinder Cone 4		Cinder Cone 5		High Peaks	
Species	No.	Status	No.	Status	No.	Status	No.	Status	No.	Status	No.	Status
White-throated Swift	6	N					3	?			4	N
Turkey Vulture											15	
Golden Eagle							0	UN?			1?	
Red-tailed Hawk	1	A	1	ON	1P	ON	1P				5	P, N
Great Horned Owl									1	ON	1	ON
American Kestrel					1						2	T
Merlin							1	M				
Prairie Falcon											1	
Common Raven	1P	ON	1		1		1P				6	N
Effort												
Dates	3/23/2021		3/23/2021		3/24/2021		3/24/2021		3/24/2021		2/20/2021	
Total time (hr:min)	0:50		1:20		0:45		1:05		0:55		6:20	

Table 7: Cactus Ferruginous Pygmy-Owl surveys completed by University of Arizona field staff in Organ Pipe Cactus National Monument in Spring 2021. Historical localities are from NPS data files. Some surveys were outside the recommended survey times for this species but conditions were suitable in all cases to detect owls. Additional surveys were completed by wildlife biologist Danny Martin throughout OPCNM and will be reported elsewhere. A total of one territorial male pygmy-owl was detected during surveys by UA staff, and another female was detected during subsequent surveys by NPS in May 2021. Locations of these observations are not provided here to protect sensitive locality information.

Dates	Start Time	End Time	Location	No. of Calling Stations	Survey Event	Rational/past status
3/9/21	6:10	12:02	Cuerda de Leña - near N. boundary	6	1st	Exploratory
3/9/21	9:45	11:40	Growler Canyon - upper section	4	1st	Historical sites, Exploratory
3/11/21	11:10	12:04	Washes south of Gunsite Hills	4	1st	Exploratory
3/11/21	6:25	12:21	Upper Kuakatch Wash	8	1st	Historical sites
4/6/21	9:36	11:20	Growler Canyon - lower section	3	1st	Historical sites
4/29/21	5:42	5:50	Estes Canyon - Rest area/wash	1	1st	Historical site
4/29-5/1/21	5:14	5:38	Diablo Mountain - Washes to West	2	1st	Historical site
4/30/21	8:15	9:40	Upper Kuakatch Wash	5	2nd	Historical sites
5/1/21	5:30	8:18	Arch Canyon - Bajada below mouth	3	1st	Historical site, Exploratory
5/14/21	5:20	8:12	Aguajita Wash - N. of Border	4	1st	Historical sites, Exploratory
5/18/21	5:12	5:20	Alamo Canyon	1	1st	Historical site
5/15,20,21/21	5:05	8:05	Lower Kuakatch - East Armenta	4	1st	Historical sites, Exploratory

Table 8: Bird species ($n = 107$) detected during point count surveys and three visits along 25 transects in Organ Pipe Cactus National Monument in February-May 2021. Totals include before count and after count detections. Mean distance is the average perpendicular detection distance recorded during distance sampling with omissions due to species being only detected before or after counts. Frequency of occurrence is the percent of transects each species was recorded. A total of 90 observations and 106 individuals are not included because they were not identified to the species level. Species are listed in taxonomic order.

Common Name	Latin Name	No. Observations	No. Individuals	Mean Distance	Frequency of Occurrence (%)
Gambel's Quail	<i>Callipepla gambelii</i>	292	670	149	100
Pied-billed Grebe	<i>Podilymbus podiceps</i>	2	2	22	4
Eurasian Collared-Dove	<i>Streptopelia decaocto</i>	33	39	133	16
Common Ground Dove	<i>Columbina passerina</i>	1	1	20	4
White-winged Dove	<i>Zenaida asiatica</i>	468	510	160	100
Mourning Dove	<i>Zenaida macroura</i>	156	195	124	100
Greater Roadrunner	<i>Geococcyx californianus</i>	96	97	171	80
Lesser Nighthawk	<i>Chordeiles acutipennis</i>	3	3	180	12
Common Poorwill	<i>Phalaenoptilus nuttallii</i>	5	5	129	16
White-throated Swift	<i>Aeronautes saxatalis</i>	14	29	171	24
Anna's Hummingbird	<i>Calypte anna</i>	12	12	28	20
Costa's Hummingbird	<i>Calypte costae</i>	97	102	40	64
Rufous Hummingbird	<i>Selasphorus rufus</i>	1	1	11	4
American Coot	<i>Fulica americana</i>	5	16	59	4
Brown Pelican	<i>Pelecanus occidentalis</i>	1	1	50	4
Green Heron	<i>Butorides virescens</i>	1	1		4
Turkey Vulture	<i>Cathartes aura</i>	37	159	216	72
Sharp-shinned Hawk	<i>Accipiter striatus</i>	1	1		4
Cooper's Hawk	<i>Accipiter cooperii</i>	6	6	78	12
Harris's Hawk	<i>Parabuteo unicinctus</i>	6	7	123	16
Swainson's Hawk	<i>Buteo swainsoni</i>	1	1		4
Red-tailed Hawk	<i>Buteo jamaicensis</i>	30	32	283	72
Western Screech-Owl	<i>Megascops kennicottii</i>	2	2	200	8
Great Horned Owl	<i>Bubo virginianus</i>	24	32	228	40
Ferruginous Pygmy-Owl	<i>Glaucidium brasilianum</i>	6	6	229	4
Gila Woodpecker	<i>Melanerpes uropygialis</i>	679	709	150	100
Ladder-backed Woodpecker	<i>Dryobates scalaris</i>	105	108	88	92
Northern Flicker	<i>Colaptes auratus</i>	2	2	10	8
Gilded Flicker	<i>Colaptes chrysoides</i>	301	308	161	100
Crested Caracara	<i>Caracara cheriway</i>	2	3	20	8
American Kestrel	<i>Falco sparverius</i>	16	16	168	40
Peregrine Falcon	<i>Falco peregrinus</i>	1	1	100	4
Prairie Falcon	<i>Falco mexicanus</i>	3	13	757	4
Ash-throated Flycatcher	<i>Myiarchus cinerascens</i>	410	443	100	100
Nutting's Flycatcher	<i>Myiarchus nuttingi</i>	1	1	25	4
Brown-crested Flycatcher	<i>Myiarchus tyrannulus</i>	170	216	138	84

Cassin's Kingbird	<i>Tyrannus vociferans</i>	3	4	27	4
Western Kingbird	<i>Tyrannus verticalis</i>	1	1		4
Olive-sided Flycatcher	<i>Contopus cooperi</i>	2	2	210	8
Western Wood-Pewee	<i>Contopus sordidulus</i>	8	8	53	28
Dusky Flycatcher	<i>Empidonax oberholseri</i>	1	1		4
Western Flycatcher	<i>Empidonax difficilis/occidentalis</i>	10	10	60	24
Black Phoebe	<i>Sayornis nigricans</i>	3	4	19	4
Say's Phoebe	<i>Sayornis saya</i>	34	34	109	52
Vermilion Flycatcher	<i>Pyrocephalus rubinus</i>	5	5	66	12
Loggerhead Shrike	<i>Lanius ludovicianus</i>	33	34	109	48
Bell's Vireo	<i>Vireo bellii</i>	5	5	71	12
Warbling Vireo	<i>Vireo gilvus</i>	11	15	30	32
Common Raven	<i>Corvus corax</i>	90	103	181	88
Tree Swallow	<i>Tachycineta bicolor</i>	4	8	44	12
Violet-green Swallow	<i>Tachycineta thalassina</i>	21	53	74	40
Northern Rough-winged Swallow	<i>Stelgidopteryx serripennis</i>	6	13	44	16
Verdin	<i>Auriparus flaviceps</i>	353	362	78	96
Rock Wren	<i>Salpinctes obsoletus</i>	56	57	107	36
Canyon Wren	<i>Catherpes mexicanus</i>	8	9	171	12
House Wren	<i>Troglodytes aedon</i>	1	2		4
Marsh Wren	<i>Cistothorus palustris</i>	2	2	44	4
Cactus Wren	<i>Campylorhynchus brunneicapillus</i>	553	559	154	92
Blue-gray Gnatcatcher	<i>Poliophtila caerulea</i>	2	3	18	4
Black-tailed Gnatcatcher	<i>Poliophtila melanura</i>	151	160	70	100
Ruby-crowned Kinglet	<i>Regulus calendula</i>	4	4	33	12
Swainson's Thrush	<i>Catharus ustulatus</i>	1	1	40	4
Hermit Thrush	<i>Catharus guttatus</i>	1	1	38	4
Curve-billed Thrasher	<i>Toxostoma curvirostre</i>	231	233	106	92
Bendire's Thrasher	<i>Toxostoma bendirei</i>	4	4	294	4
Crissal Thrasher	<i>Toxostoma crissale</i>	8	8	84	20
Sage Thrasher	<i>Oreoscoptes montanus</i>	1	1	63	4
Northern Mockingbird	<i>Mimus polyglottos</i>	76	80	127	80
European Starling	<i>Sturnus vulgaris</i>	10	25	73	12
Phainopepla	<i>Phainopepla nitens</i>	387	450	99	92
House Sparrow	<i>Passer domesticus</i>	1	1		4
House Finch	<i>Haemorhous mexicanus</i>	263	365	70	96
Pine Siskin	<i>Spinus pinus</i>	10	24	59	32
Lesser Goldfinch	<i>Spinus psaltria</i>	7	7	45	28
Black-throated Sparrow	<i>Amphispiza bilineata</i>	265	339	64	100
Lark Sparrow	<i>Chondestes grammacus</i>	1	1	26	4
Lark Bunting	<i>Calamospiza melanocorys</i>	1	3	110	4
Black-chinned Sparrow	<i>Spizella atrogularis</i>	2	2	93	4
Brewer's Sparrow	<i>Spizella breweri</i>	23	62	60	24
Dark-eyed Junco	<i>Junco hyemalis</i>	4	13	40	4
White-crowned Sparrow	<i>Zonotrichia leucophrys</i>	84	171	40	84

Song Sparrow	<i>Melospiza melodia</i>	1	2	21	4
Lincoln's Sparrow	<i>Melospiza lincolnii</i>	4	5	69	8
Canyon Towhee	<i>Melospiza fusca</i>	59	72	61	48
Rufous-crowned Sparrow	<i>Aimophila ruficeps</i>	41	49	74	16
Green-tailed Towhee	<i>Pipilo chlorurus</i>	4	4	118	16
Spotted Towhee	<i>Pipilo maculatus</i>	6	7	60	4
Western Meadowlark	<i>Sturnella neglecta</i>	4	6	42	8
Hooded Oriole	<i>Icterus cucullatus</i>	11	11	66	16
Bullock's Oriole	<i>Icterus bullockii</i>	1	1		4
Scott's Oriole	<i>Icterus parisorum</i>	66	67	118	68
Red-winged Blackbird	<i>Agelaius phoeniceus</i>	1	1	250	4
Brown-headed Cowbird	<i>Molothrus ater</i>	33	39	57	36
Orange-crowned Warbler	<i>Leiothlypis celata</i>	22	29	33	44
Lucy's Warbler	<i>Leiothlypis luciae</i>	158	162	56	68
Common Yellowthroat	<i>Geothlypis trichas</i>	3	6	26	4
Yellow Warbler	<i>Setophaga petechia</i>	4	4	27	16
Yellow-rumped Warbler	<i>Setophaga coronata</i>	6	9	29	16
Black-throated Gray Warbler	<i>Setophaga nigrescens</i>	2	2	10	8
Townsend's Warbler	<i>Setophaga townsendi</i>	20	23	35	48
Hermit Warbler	<i>Setophaga occidentalis</i>	1	1	18	4
Wilson's Warbler	<i>Cardellina pusilla</i>	47	54	29	48
Western Tanager	<i>Piranga ludoviciana</i>	8	8	48	24
Northern Cardinal	<i>Cardinalis cardinalis</i>	28	30	86	40
Pyrrhuloxia	<i>Cardinalis sinuatus</i>	6	6	117	16
Black-headed Grosbeak	<i>Pheucticus melanocephalus</i>	13	13	48	32
Lazuli Bunting	<i>Passerina amoena</i>	6	6	43	24

Table 9: Pearson correlation coefficients between temporal, geographic, disturbance, weather, and vegetation factors, and the three dimensional nonmetric multidimensional scaling configuration of sites in breeding bird species space (see Figure 3). A total of 19 sites were considered across 126 site-years across Organ Pipe Cactus Nation Monument between 1993 and 2021. Coefficients ≥ 0.45 are in bold for emphasis.

Group Factor	Axis 1	Axis 2	Axis 3
Time			
Year	-0.24	0.14	-0.48
Period 3 (1990s, 2000s, 2021)	-0.37	0.10	-0.45
Period 2 (1990-2000s vs. 2021)	-0.58	0.02	-0.36
Space			
Latitude	-0.35	-0.24	-0.09
Longitude	-0.32	0.17	0.25
Elevation	-0.40	0.49	0.42
Method			
Belt transect (1) vs. Point count (2)	-0.76	0.05	-0.34
Disturbance			
Border impacts (0-3; none-high)	0.51	-0.07	-0.13
General Environment			
Landform (1-mts, 2-bajada, 3-valley)	0.06	-0.73	-0.05
Hydrology (1-upland, 2-mixed, 3-riparian)	0.11	-0.71	0.37
Vegetation (1-shrubland, 2-mixed, 3-woodland)	0.05	-0.59	0.50
Temperature (T)			
Mean annual (Feb-Mar)	-0.19	0.16	-0.22
Mean annual - 2 yr avg	-0.33	0.15	-0.20
Mean annual - 3 yr avg	-0.37	0.18	-0.20
Mean annual - 4 yr avg	-0.34	0.23	-0.23
Mean annual - 5 yr avg	-0.33	0.25	-0.24
Warm season, current	-0.15	-0.16	-0.31
Cool season, current	-0.15	0.41	-0.02
Hottest month	-0.14	-0.15	-0.37
Coldest month	-0.09	0.47	-0.02
Precipitation (P)			
Annual (Feb-Mar)	0.26	0.14	0.55
Annual - 2 yr avg	0.41	0.26	0.59
Annual - 3 yr avg	0.47	0.31	0.55
Annual - 4 yr avg	0.36	0.27	0.61
Annual - 5 yr avg	0.29	0.27	0.64
Warm season (prior Apr-Sept)	0.04	0.23	0.37
Cool season (prior Oct-Mar)	0.32	0.00	0.44
Vegetation			
Tree cover	0.14	-0.29	0.56
<i>Larrea</i> cover	0.43	-0.40	-0.40
Woody cover	0.31	-0.42	0.25
Tree cover - % change	0.16	-0.27	0.16
<i>Larrea</i> cover - % change	0.25	0.05	0.18
Woody cover - % change	0.14	-0.29	0.22

Table 10: Nonmetric multidimensional scaling and blocked indicator species analysis (bISA) results for breeding bird communities at 19 sites in Organ Pipe Cactus National Monument between 1993 and 2021. Pearson correlation coefficients (r) are correlations between the 3 ordination axes and species' relative abundance data. Habitat affinity notes group used to help interpret results and are depicted in color in Figure 3. Relative abundance indicated % of perfect indication or average species abundance in each time period over average species abundance in all plots. Group of maximum association (Max. group) notes the time period most associated with relative abundance of each species and associated P -value from bISA. Species are ordered taxonomically. Sample sizes (n) are in site years.

Code	Common Name	Axis 1	Axis 2	Axis 3	r_1	r_2	r_3	Habitat affinity	Relative Abundance			bISA		
									Group 1 1990s ($n = 59$)	Group 2 2000s ($n = 48$)	Group 3 2021 ($n = 19$)	Max. group	Indicator Value	P
GAQU	Gambel's Quail	-0.193	-0.175	-0.060	-0.588	-0.572	-0.260	Desertscrub	26	25	48	3	49	0.053
EUCD	Eurasian Collared-Dove	0.218	-0.209	-0.928	0.055	-0.056	-0.328	Non-native, Humans	0	0	100	3	21	0.008
WWDO	White-winged Dove	-0.083	-0.129	-0.012	-0.366	-0.606	-0.072	Desertscrub	32	26	42	3	42	0.731
MODO	Mourning Dove	-0.098	-0.184	0.003	-0.265	-0.533	0.012	Generalist	39	30	31	1	39	0.913
GRRO	Greater Roadrunner	-0.182	-0.136	-0.219	-0.253	-0.203	-0.430	Open country	12	24	65	3	51	0.000
WTSW	White-throated Swift	-0.484	0.578	0.248	-0.323	0.412	0.233	Mt Slopes-Cliffs	19	24	56	3	18	0.126
ANHU	Anna's Hummingbird	0.103	-0.072	-0.076	0.039	-0.029	-0.040	Nectar	12	0	88	3	23	0.003
COHU	Costa's Hummingbird	-0.428	0.094	0.109	-0.691	0.161	0.247	Nectar	19	33	49	3	33	0.061
TUVU	Turkey Vulture	-0.031	-0.099	-0.078	-0.037	-0.127	-0.132	Generalist	16	17	67	3	53	0.000
HASH	Harris's Hawk	-0.120	-0.439	0.152	-0.046	-0.178	0.081	Woodland-Shrub	37	63	0	2	4	0.658
ZTHA	Zone-tailed Hawk	-0.606	-0.428	0.194	-0.243	-0.183	0.110	Woodland-Shrub	6	94	0	2	14	0.012
RTHA	Red-tailed Hawk	-0.116	0.091	-0.222	-0.137	0.115	-0.370	Open country	15	15	70	3	52	0.000
FEPO	Ferruginous Pygmy-Owl	-0.651	-0.444	0.061	-0.256	-0.187	0.034	Woodland-Shrub	21	69	10	2	10	0.224
GIWO	Gila Woodpecker	-0.199	0.009	-0.017	-0.697	0.035	-0.083	Cavities	25	23	53	3	53	0.001
LBWO	Ladder-backed Woodpecker	-0.258	-0.059	0.005	-0.618	-0.151	0.017	Cavities	17	25	59	3	55	0.001
GIFL	Gilded Flicker	-0.107	0.087	-0.094	-0.372	0.323	-0.461	Cavities	28	21	51	3	49	0.079
AMKE	American Kestrel	-0.149	0.028	-0.239	-0.168	0.034	-0.382	Open country	28	30	42	3	16	0.779
PRFA	Prairie Falcon	-0.613	0.611	0.294	-0.269	0.287	0.182	Mt Slopes-Cliffs	12	39	49	2	6	0.449
ATFL	Ash-throated Flycatcher	-0.180	0.006	-0.059	-0.706	0.026	-0.326	Cavities	27	26	47	3	47	0.058
BCFL	Brown-crested Flycatcher	-0.315	-0.015	0.054	-0.624	-0.032	0.150	Cavities	18	22	60	3	47	0.025
SAPH	Say's Phoebe	-0.366	0.419	-0.001	-0.345	0.423	-0.001	Open country	10	23	66	3	42	0.002
VEFL	Vermilion Flycatcher	0.143	-0.777	-0.046	0.079	-0.455	-0.036	Woodland-Shrub	41	12	47	1	8	0.694
LOSH	Loggerhead Shrike	0.159	0.201	-0.446	0.150	0.202	-0.592	Open country	19	23	58	3	24	0.131

BEVI	Bell's Vireo	-0.062	-0.642	0.197	-0.066	-0.732	0.296	Woodland-Shrub	61	26	12	1	28	0.047
CORA	Common Raven	-0.081	-0.067	-0.132	-0.174	-0.155	-0.400	Generalist	24	25	52	3	49	0.002
VGSW	Violet-green Swallow	0.453	-0.117	-0.109	0.313	-0.086	-0.107	Cavities	30	8	62	3	26	0.016
PUMA	Purple Martin	-0.094	-0.300	0.071	-0.033	-0.112	0.035	Cavities	70	30	0	1	7	0.169
VERD	Verdin	-0.142	-0.128	0.012	-0.511	-0.495	0.060	Desertscrub	34	26	41	3	39	0.715
ROWR	Rock Wren	-0.498	0.419	0.182	-0.502	0.453	0.259	Mt Slopes-Cliffs	20	26	54	3	23	0.105
CANW	Canyon Wren	-0.357	0.307	0.337	-0.373	0.343	0.496	Mt slopes-Cliffs	42	49	9	2	22	0.034
CACW	Cactus Wren	-0.212	0.166	-0.049	-0.572	0.479	-0.187	Desertscrub	33	22	45	3	40	0.612
BTGN	Black-tailed Gnatcatcher	-0.138	-0.044	0.009	-0.598	-0.206	0.056	Desertscrub	33	27	40	3	40	0.976
CBTH	Curve-billed Thrasher	-0.172	0.060	0.019	-0.540	0.200	0.085	Desertscrub	34	25	40	3	36	0.950
BETH	Bendire's Thrasher	-0.006	0.148	-0.202	-0.002	0.047	-0.085	Open country	13	47	40	2	3	0.511
CRTH	Crissal Thrasher	-0.366	-0.581	0.129	-0.305	-0.518	0.152	Woodland-Shrub	20	30	51	3	13	0.356
NOMO	Northern Mockingbird	-0.218	-0.333	-0.033	-0.371	-0.606	-0.080	Desertscrub	33	31	36	3	32	0.921
EUST	European Starling	0.248	-0.230	-0.695	0.067	-0.067	-0.266	Non-native, Humans	18	0	82	3	13	0.166
PHAI	Phainopepla	-0.153	-0.253	0.060	-0.394	-0.700	0.219	Desertscrub	37	29	34	1	34	0.977
HOSP	House Sparrow	0.245	-0.394	-0.222	0.045	-0.077	-0.057	Non-native, Humans	24	0	76	3	4	0.579
HOFI	House Finch	-0.163	0.167	0.057	-0.479	0.525	0.237	Desertscrub	30	25	45	3	45	0.362
LEGO	Lesser Goldfinch	-0.126	0.015	0.337	-0.133	0.017	0.504	Seeds	39	27	35	1	19	0.622
RWSP	Rufous-winged Sparrow	0.251	-0.596	0.286	0.082	-0.207	0.131	Woodland-Shrub	100	0	0	1	10	0.041
BTSP	Black-throated Sparrow	-0.322	0.087	-0.104	-0.710	0.204	-0.325	Desertscrub	17	25	58	3	58	0.003
CANT	Canyon Towhee	-0.316	-0.011	0.148	-0.699	-0.025	0.463	Shrubs	35	41	24	2	39	0.037
RCSP	Rufous-crowned Sparrow	-0.459	0.566	0.346	-0.271	0.357	0.288	Mt Slopes-Cliffs	28	45	28	2	12	0.231
HOOR	Hooded Oriole	-0.158	-0.282	0.203	-0.210	-0.402	0.382	Woodland-Shrub	46	45	9	2	28	0.127
SCOR	Scott's Oriole	-0.265	0.274	0.010	-0.441	0.487	0.025	Mt Slopes-Cliffs	25	27	48	3	30	0.311
RWBL	Red-winged Blackbird	0.822	-0.554	-0.173	0.280	-0.202	-0.084	Non-native, Humans	77	0	23	1	7	0.410
BHCO	Brown-headed Cowbird	0.056	-0.198	0.136	0.133	-0.505	0.458	Parasite	52	34	15	1	47	0.071
GTGR	Great-tailed Grackle	1.006	-0.441	0.058	0.485	-0.227	0.039	Non-native, Humans	100	0	0	1	20	0.046
LUWA	Lucy's Warbler	-0.041	-0.485	0.005	-0.061	-0.767	0.011	Woodland-Shrub	22	23	55	3	37	0.072
NOCA	Northern Cardinal	-0.264	-0.006	0.183	-0.474	-0.012	0.465	Shrubs	36	30	34	1	24	0.944
PYRR	Pyrrhuloxia	-0.152	-0.305	0.141	-0.164	-0.351	0.214	Shrubs	56	33	11	1	24	0.078

Table 11: Trends in cover of leguminous trees and creosote bush within 150 m plots around 194 point-count stations used to monitor birds in Organ Pipe Cactus National Monument between 1995 and 2021. Cover data are from 4 years (1995, 1999, 2005, 2009) and measured using classification models and Landsat data (see Munson et al. 2016). Parameter estimates indicate % annual change based on linear mixed effects models with point and transect fit as random effects. Parenthetical numbers for groupings (bold) are sample sizes (e.g., points x years) and for classification types (not bold) are *P*-values from *F*-tests for year by classification type interaction terms. *P*-values are based on Satterthwaite's method.

	Leguminous Trees			Creosote Bush		
	Est.	SE	<i>P</i>	Est.	SE	<i>P</i>
All Points (776)	-1.04	0.111	<0.0001	-0.024	0.052	0.64
Hydrologic Type (<0.01; <0.01)						
Riparian (276)	-1.00	0.180	<0.0001	0.030	0.094	0.75
Mixed (104)	-2.65	0.504	<0.0001	0.43	0.180	0.020
Upland (396)	-0.64	0.108	<0.0001	-0.18	0.059	0.0024
Vegetation Type (0.07; 0.14)						
Woodland (232)	-0.65	0.111	<0.0001	-0.12	0.099	0.23
Mixed (388)	-1.21	0.188	<0.0001	0.078	0.079	0.32
Shrubland (156)	-1.19	0.240	<0.0001	-0.13	0.070	0.059
Landform (0.03; <0.01)						
Valley Bottom (180)	-0.70	0.144	<0.0001	-0.082	0.098	0.41
Bajada (464)	-1.27	0.174	<0.0001	0.13	0.056	0.025
Rockslope-Canyon (132)	-0.66	0.112	<0.0001	-0.47	0.181	0.010



Figure 1. Point transects used to monitor bird communities in Organ Pipe Cactus National Monument in 2021, and locations of 18 focal weather stations and/or rain gauges used for weather attributes. Transect names are noted in all capital letters. Those named “U” and “R” were installed by the Sonoran Desert Network in 2007 but were not considered here because we were unable to obtain past data for analyses.



Figure 2. Locations of point transects used to monitor bird communities in Pinacate Biosphere Reserve in 2021. Cono Rojo and Dunas are new transects that were added to eight other sites monitored previously by reserve staff. Sites names are in all capital letters and sites in adjacent Organ Pipe Cactus National Monument are shown for context.

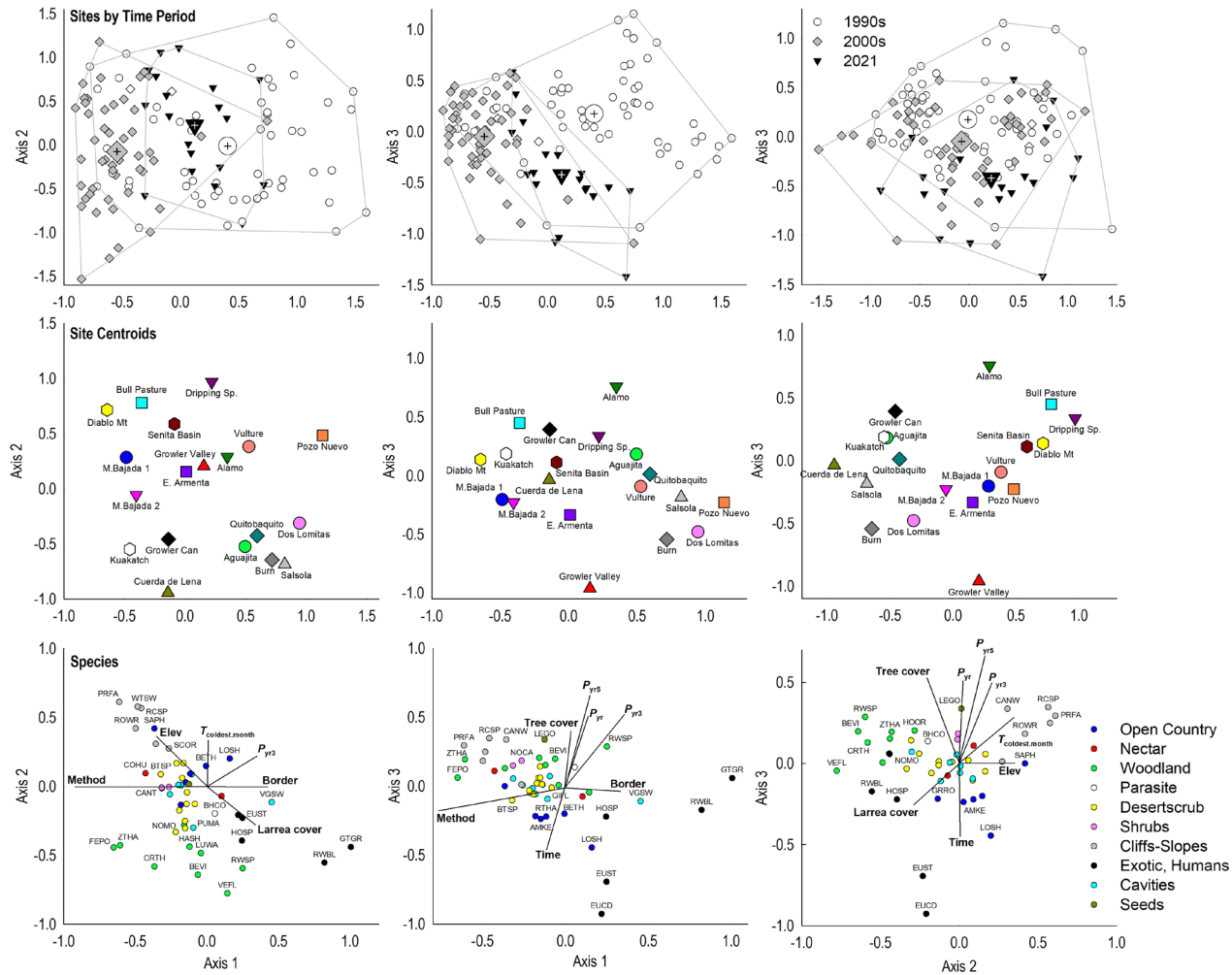


Figure 3. Three-dimensional nonmetric multidimensional scaling ordination of breeding bird communities at 19 sites across 126 site years of effort in Organ Pipe Cactus National Monument, 1993-2021. Top panel shows spatiotemporal variation in communities with convex hulls and large-symbolled centroids highlighting three time periods. Middle panel shows site centroids in species space. Bottom panel shows results for 50 species with habitat affinity groups as colors and representative species labelled with mnemonic codes (see Table X; 3 habitat generalists were omitted). Vectors show correlations between ordination results and environmental factors (see Table X), point in directions factors vary most in ordination space, and have lengths scaled to magnitudes of correlation. Results based on Sørensen distances and square-root transformed relative abundance data (stress = 0.118).

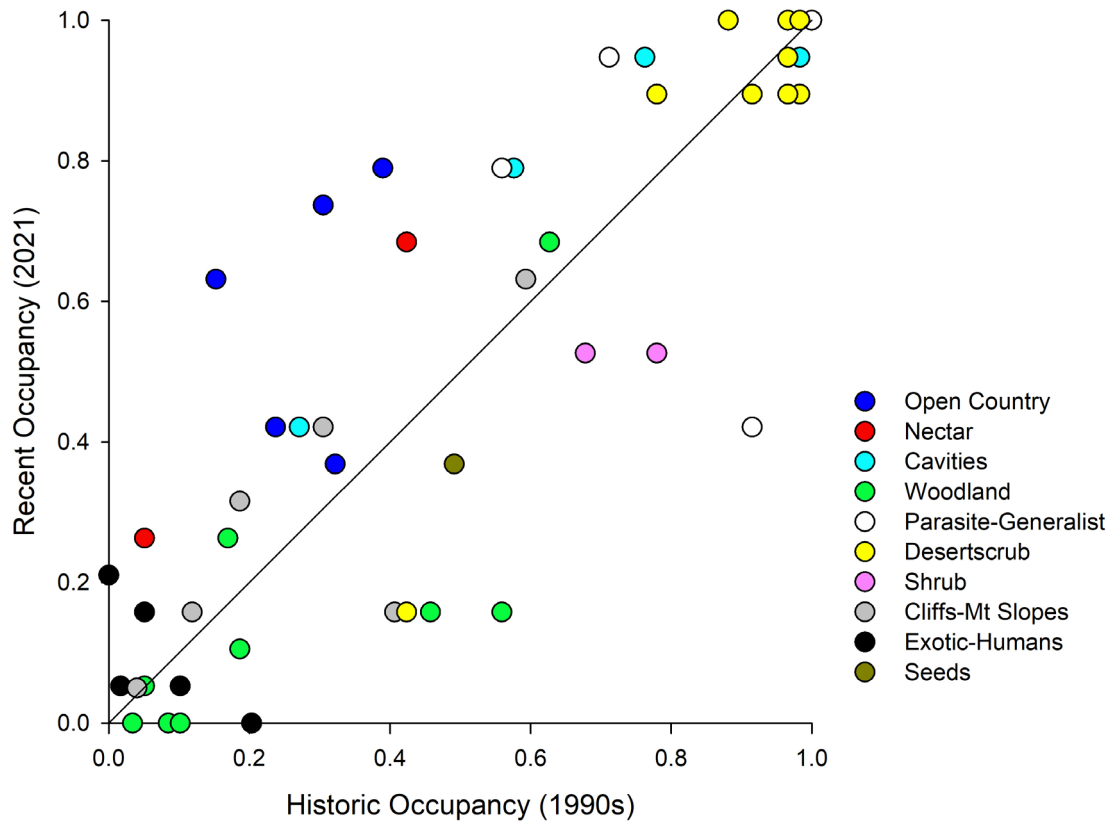


Figure 4. Historical (1990s) versus recent (2021) observed occurrence probabilities of 53 regularly-occurring breeding bird species in Organ Pipe Cactus National Monument, 1993-2021. Points are the proportion of site years that each species was observed during 3-6 visits to each site within a year in each period. The 1990s period included 59 site years of visits between 1993 and 1999, and the 2021 period included 19 sites years and 57 site visits total. Species are colored by habitat affinities.

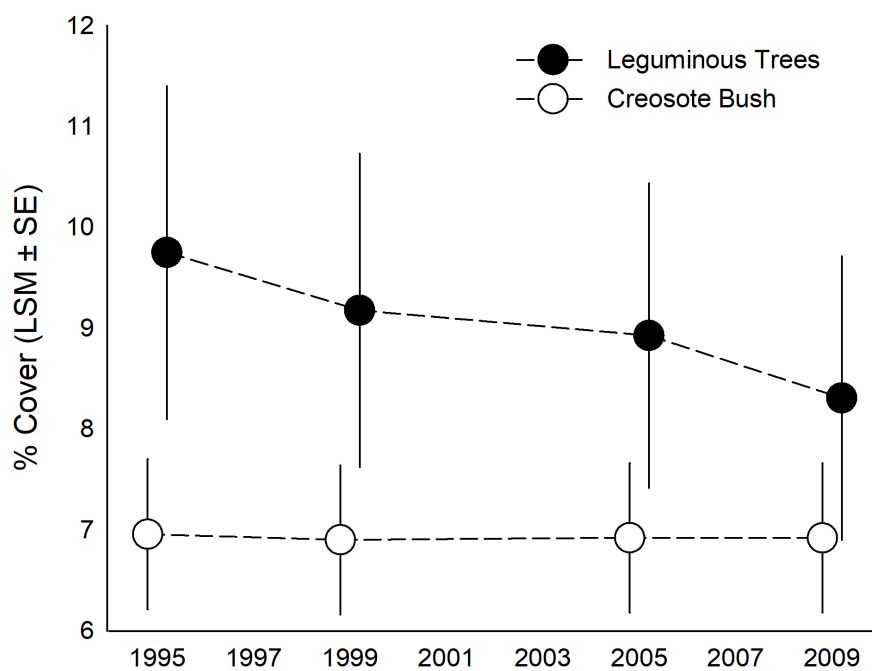


Figure 5. Variation in leguminous tree and creosote bush cover within 150 m plots around 194 point-count stations in Organ Pipe Cactus National Monument over four years between 1995 and 2009. Cover data are based on classification models and Landsat data (see Munson et al. 2016) and estimates are least-square means and standard errors from linear mixed effects models with point and transect fit as random effects and year fit a fixed effect.

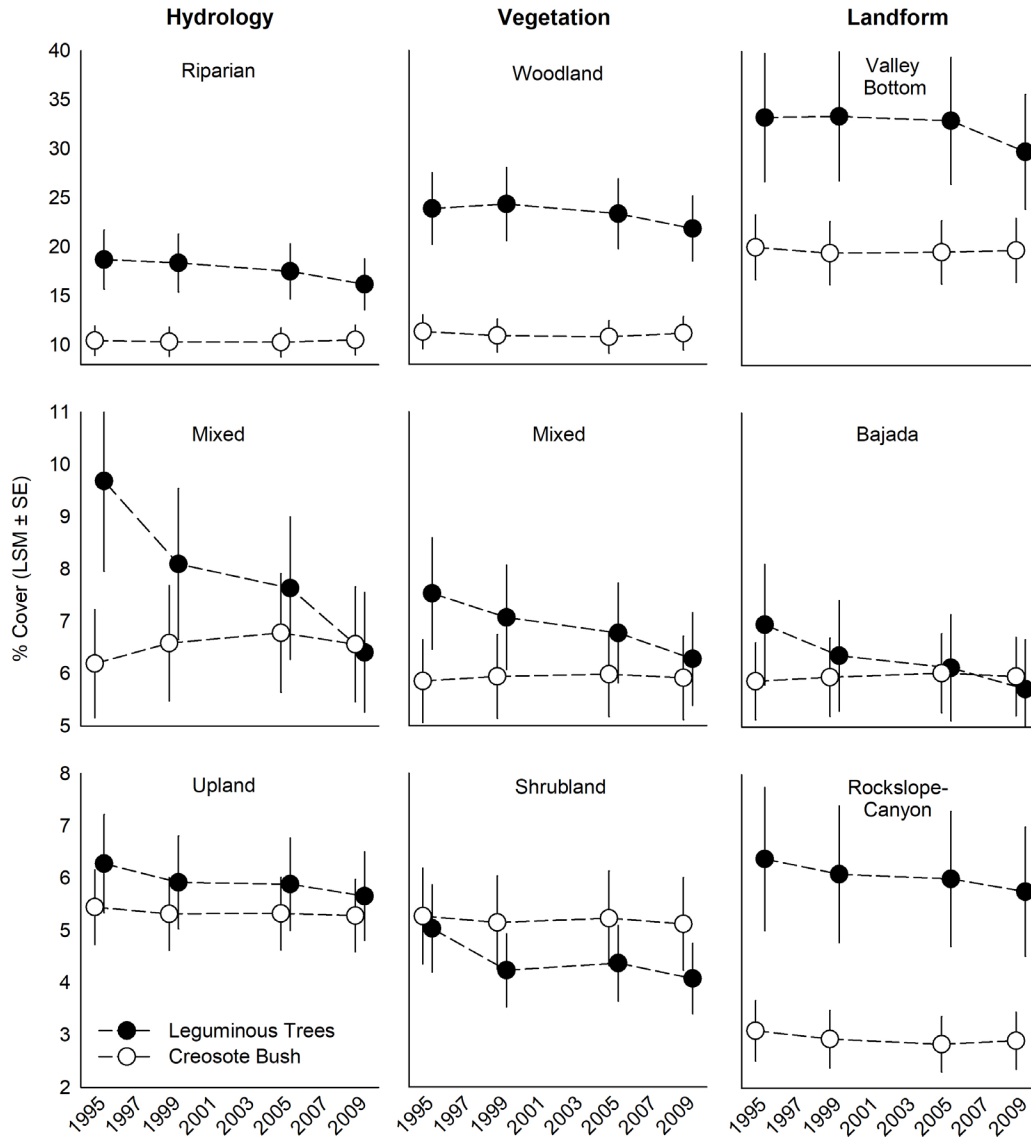


Figure 6. Variation in leguminous tree and creosote bush cover within 150 m plots around 194 point-count stations in each of three different hydrologic, vegetation, and landform types across Organ Pipe Cactus National Monument during four years between 1995 and 2009. Cover data are based on classification models and Landsat data (see Munson et al. 2016) and are least-square means from linear mixed effects models with point and transect fit as random effects and year fit a fixed effect.

Appendix A: Photos showing various project activities in Organ Pipe Cactus National Monument and Pinacate Biosphere Reserve in 2021.



Avian field training in Mexico in Feb 2021 led by UA project staff Aaron Flesch and Miguel Grageda (CEDO)



Some participants that attended workshops at Pinacate Biosphere Reserve in Mexico in Feb 2021 (A. Flesch)



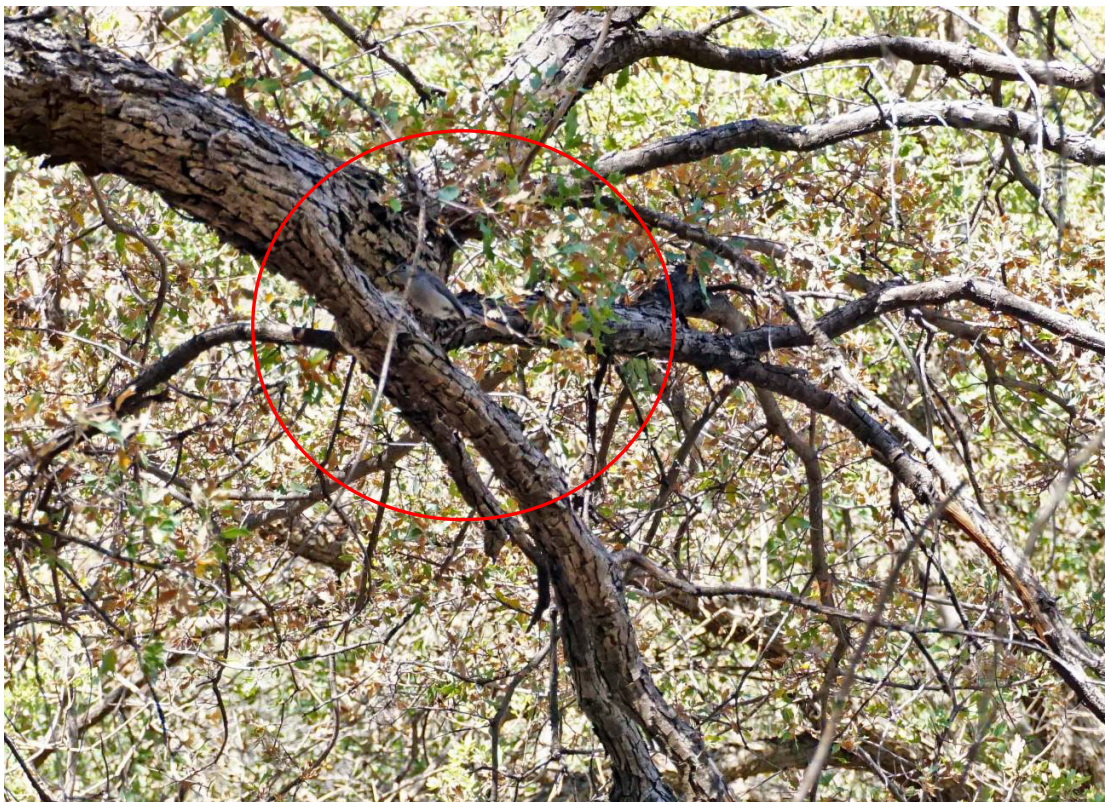
UA Project staff Miguel Grageda leading workshop at Pinacate Biosphere Reserve in Mexico in Feb 2021 (A. Flesch)



Raptor survey field training at Elegant Crater in Pinacate Biosphere Reserve in Mexico in Feb 2021. (CEDO)



Participants in avian field training in OPCNM in late Feb. 2021 led by UA project staff Aaron Flesch and attended by three NPS biologists. (A. Flesch)



Blue-gray Gnatcatcher building a nest in an oak in the Ajo Mountains, OPCNM, May 2021. This is likely the first confirmed breeding record for the species in OPCNM. (A. Flesch)

Appendix B: Correspondence with Sonoran Desert Network staff associated with our efforts to acquire their 2007-2015 bird monitoring data for Organ Pipe Cactus National Monument. Failure to obtain these data resulted in a 16-year gap in time-series information and limited inferences somewhat. Once made available, these data can be integrated into analyses in the future.

[EXT]Re: [EXTERNAL] SOND bird data for 2021 ORPI project

Thomas, Helen M <Helen_Thomas@nps.gov>

Tue 12/21/2021 8:23 PM

To: Flesch, Aaron D - (flesch) <flesch@ag.arizona.edu>

Cc: Holm, Peter A <Peter_Holm@nps.gov>

External Email

Hi, Aaron -

My sincere apologies for not getting the data ready in time for your current project. I feel really bad about that. We are currently working on taxonomy updates, which has been a bit more of an effort than we had expected.

I can explain more when we talk. I will try to call you tomorrow. I look forward to hearing more about your recent proposal.

Helen Thomas
Data Manager
National Park Service
[Sonoran Desert Network](#)
(435) 260-9858

From: Flesch, Aaron D - (flesch) <flesch@ag.arizona.edu>
Sent: Monday, December 20, 2021 1:39 PM
To: Thomas, Helen M <Helen_Thomas@nps.gov>
Cc: Holm, Peter A <Peter_Holm@nps.gov>
Subject: Re: [EXTERNAL] SOND bird data for 2021 ORPI project

Thanks Helen!!

Happy to chat tomorrow, Wed, or Thurs (520-730-4656). Mostly free those days and in the office here

Should we get a data use agreement in place too with UA and ORPI?

No super rush as we had to move our analyses along without these data for now. That said, Peter and I just submitted a new proposal to expand efforts on Fri, which will allow us to use these data and that from 2022-23 work

regards
Aaron

From: Thomas, Helen M <Helen_Thomas@nps.gov>
Sent: Monday, December 20, 2021 10:27 AM

To: Flesch, Aaron D - (flesch) <flesch@ag.arizona.edu>
Cc: Holm, Peter A <Peter_Holm@nps.gov>
Subject: [EXT]Re: [EXTERNAL] SOND bird data for 2021 ORPI project

External Email

Hi, Aaron -

Would you have a few minutes to chat about the status of the dataset? We are getting close, but we still have a little work to do and now we are running up against the holidays. I am available most anytime today through Wednesday.

Thanks!

Helen Thomas
Data Manager
National Park Service
[Sonoran Desert Network](#)
(435) 260-9858

From: Flesch, Aaron D - (flesch) <flesch@ag.arizona.edu>
Sent: Monday, November 1, 2021 1:25 PM
To: Thomas, Helen M <Helen_Thomas@nps.gov>
Cc: Holm, Peter A <Peter_Holm@nps.gov>
Subject: Re: [EXTERNAL] SOND bird data for 2021 ORPI project

Thanks Helen!

Appreciate your time and attention to this. Yes, still hoping to get the work done by end of Dec. but we can get a short extension if needed.

I'm also waiting for some environmental data from Peter that is higher priority, so know I&M is not currently holding us up a ton

Peter was able to send the attached summary of the total counts for each transect and year that he received from SODN yrs ago, but we are hoping to get the pt by pt level data with the distance estimates too.

So far as Metadata go, the main need is knowing the count time (6 or 8 min I think?) in each year at the stations.

Thanks a ton!
Aaron

From: Thomas, Helen M <Helen_Thomas@nps.gov>
Sent: Monday, November 1, 2021 1:11 PM

To: Flesch, Aaron D - (flesch) <flesch@ag.arizona.edu>
Cc: Holm, Peter A <Peter_Holm@nps.gov>
Subject: [EXT]Re: [EXTERNAL] SOND bird data for 2021 ORPI project

External Email

Hi, Aaron -

Touching base again. We are still preparing the data. It is taking longer than expected to track down some of the metadata and to resolve some issues, but we are making good progress. My sincere apologies for the delay.

Are you still working towards an end of calendar year deadline?

Helen Thomas
Data Manager
National Park Service
[Sonoran Desert Network](#)
(435) 260-9858

From: Flesch, Aaron D - (flesch) <flesch@ag.arizona.edu>
Sent: Monday, September 27, 2021 10:25 AM
To: Thomas, Helen M <Helen_Thomas@nps.gov>
Cc: Holm, Peter A <Peter_Holm@nps.gov>
Subject: Re: [EXTERNAL] SOND bird data for 2021 ORPI project

Thanks Helen!

We appreciate your help.

A bit into Oct. can work. I'm currently crunching what I have but we can incorporate more yrs and sites as we go

regards
Aaron

From: Thomas, Helen M <Helen_Thomas@nps.gov>
Sent: Friday, September 24, 2021 5:46 PM
To: Flesch, Aaron D - (flesch) <flesch@ag.arizona.edu>
Cc: Holm, Peter A <Peter_Holm@nps.gov>
Subject: [EXT]Re: [EXTERNAL] SOND bird data for 2021 ORPI project

External Email

Hi, Aaron -

I wanted to touch base and let you know that we are preparing the data. I expect it will take another couple weeks or so. Would it be acceptable to deliver the data to you by mid-October? If not, please let me know and we will figure out a way to get it ready sooner.

Thanks for your patience!

Helen Thomas
Data Manager
National Park Service
[Sonoran Desert Network](#)
(435) 260-9858

From: Thomas, Helen M <Helen_Thomas@nps.gov>
Sent: Friday, September 3, 2021 6:04 PM
To: Flesch, Aaron D - (flesch) <flesch@ag.arizona.edu>
Cc: Holm, Peter A <Peter_Holm@nps.gov>
Subject: Re: [EXTERNAL] SOND bird data for 2021 ORPI project

Thanks for the target dates. That really helps. Some of the folks I need to talk to were out this week, so I will get back to you next week.

Have a nice holiday weekend!

Helen Thomas
Data Manager
National Park Service
[Sonoran Desert Network](#)
(435) 260-9858

From: Flesch, Aaron D - (flesch) <flesch@ag.arizona.edu>
Sent: Wednesday, September 1, 2021 10:06 AM
To: Thomas, Helen M <Helen_Thomas@nps.gov>
Cc: Holm, Peter A <Peter_Holm@nps.gov>
Subject: Re: [EXTERNAL] SOND bird data for 2021 ORPI project

Thanks Helen.

Figured you may be away from office. Target is to get all data together this month, do analyses in Oct - early Nov, and have a draft report out by end of Fall as our deadline is this Dec.

Thanks!
Aa

From: Thomas, Helen M <Helen_Thomas@nps.gov>
Sent: Tuesday, August 31, 2021 9:28 PM
To: Flesch, Aaron D - (flesch) <flesch@ag.arizona.edu>
Cc: Holm, Peter A <Peter_Holm@nps.gov>
Subject: [EXT]Re: [EXTERNAL] SOND bird data for 2021 ORPI project

External Email

Hi, Aaron -

My apologies for not responding yet. Today was my first day back in the office since 8/18 and apparently my out-of-office message was not set up correctly. I will discuss this with our DM team over the next day or so and get back to you by the end of the week.

Helen Thomas
Data Manager
National Park Service
[Sonoran Desert Network](#)
(435) 260-9858

From: Flesch, Aaron D - (flesch) <flesch@ag.arizona.edu>
Sent: Tuesday, August 31, 2021 2:04 PM
To: Thomas, Helen M <Helen_Thomas@nps.gov>
Cc: Holm, Peter A <Peter_Holm@nps.gov>
Subject: Re: [EXTERNAL] SOND bird data for 2021 ORPI project

Hi Helen

Just checking back in since my message from 2 wks ago. Have we made any progress since your Feb note on a data sharing agreement?

Would it be easier if the NPS park unit (ORPI) linked to this project requested these data for their unit noting UA as a collaborator?

I am CCing Peter Holm at ORPI who would make that request and with whom I am collaborating on a unit wide analysis of changes in bird communities since the 1980s

Thanks!
Aaron

From: Flesch, Aaron D - (flesch) <flesch@ag.arizona.edu>
Sent: Thursday, August 19, 2021 1:49 PM
To: Thomas, Helen M <Helen_Thomas@nps.gov>
Subject: Re: [EXTERNAL] SOND bird data for 2021 ORPI project

Hi Helen

Hope my note finds you well and enjoying the record monsoon. I've been in MT since June but watching the rain on the radar

I wanted to re-start our discussions from this past winter re. acquiring I&M's bird point count data for ORPI and SAGE-RMD

This past spring, Dr. Peter Holm and I revisited and counted ~25 pt transects, 3 times in ORPI

including the 5 I&M transects. I'm now working on organizing all the bird survey data going back to the 1980s with ORPI staff in prep. for some analyses. I have everything ORPI had on file but hope to include I&M data, which fills some major gaps. I'm happy to send you our data from 2021 if you want it. Any data you provide will be shared with ORPI Nat. Res. staff (Peter and Danny).

If it is more efficient to request other data simultaneously, I also have a project in SAGE-RMD starting in April. The idea is to assess fire and climate impacts on bird communities and the work may benefit from revisiting some I&M transects, which I counted myself with Brian Powell many moons ago. This project is also funded by NPS and will include some help from USDA-RMRS in Flagstaff, and so I'd like to share these data with USDA if it is OK with your and your office

Please let me know any concerns you may have or data sharing/request forms there may be, and I will fill them out.

Thanks a ton for your time!
Aaron

From: Flesch, Aaron D - (flesch) <flesch@ag.arizona.edu>
Sent: Monday, February 8, 2021 11:31 AM
To: Thomas, Helen M <Helen_Thomas@nps.gov>
Subject: Re: [EXTERNAL] SOND bird data for 2021 ORPI project

Thanks much Helen!

Appreciate the help

Looks like RMBO switched to 6 min (vs 8) counts in 2010 SOND-wide, so that is a fairly major change

We will probably go with 8 min counts like the other EMP points in ORPI

regards
Aaron

From: Thomas, Helen M <Helen_Thomas@nps.gov>
Sent: Monday, February 8, 2021 11:06 AM
To: Flesch, Aaron D - (flesch) <flesch@ag.arizona.edu>
Subject: [EXT]Re: [EXTERNAL] SOND bird data for 2021 ORPI project

External Email

Hi, Aaron -

It was good to speak with you today. As promised, I've attached an updated spreadsheet with the current location names for the ORPI bird transects. Also, here are links to the latest versions of the

[protocol](#) and [SOPs/datasheets](#).

Hope your field work goes well. I will work on preparing the data for sharing and the data sharing agreement over the coming months.

Take care.

Helen Thomas
Data Manager
National Park Service
[Sonoran Desert Network](#)
(435) 260-9858

From: Flesch, Aaron D - (flesch) <flesch@ag.arizona.edu>
Sent: Friday, February 5, 2021 9:48 AM
To: Thomas, Helen M <Helen_Thomas@nps.gov>
Subject: Re: [EXTERNAL] SOND bird data for 2021 ORPI project

Thanks Helen

That works!

Can you confirm these are the NAD 83 UTM's and the right number and names of the bird transects for ORPI, please? ORPI highlighted

I was I&M's bird contractor in 2008 so I have these and some other files

cheers
Aaron

From: Thomas, Helen M <Helen_Thomas@nps.gov>
Sent: Friday, February 5, 2021 8:45 AM
To: Flesch, Aaron D - (flesch) <flesch@ag.arizona.edu>
Subject: [EXT]Re: [EXTERNAL] SOND bird data for 2021 ORPI project

External Email

Hi, Aaron -

Thanks for the additional details about your needs. How about 10 am on Monday? What is a good number for you? Alternatively, you can call me at the number below.

Helen Thomas
Data Manager
National Park Service
[Sonoran Desert Network](#)
(435) 260-9858

From: Flesch, Aaron D - (flesch) <flesch@ag.arizona.edu>
Sent: Thursday, February 4, 2021 9:44 AM
To: Thomas, Helen M <Helen_Thomas@nps.gov>
Subject: Re: [EXTERNAL] SONDB bird data for 2021 ORPI project

Hi Helen

I can do Monday. In the field Thurs-Fri into the following week

Main need I have now is getting the UTM coord. in WGS 84 and the names and station numbers of all the pt count routes in OPCNM. The actual data are less important until summer when I'll start the analyses

We hope to start surveys end of this month

regards
Aa

From: Thomas, Helen M <Helen_Thomas@nps.gov>
Sent: Wednesday, February 3, 2021 5:23 PM
To: Flesch, Aaron D - (flesch) <flesch@ag.arizona.edu>
Subject: [EXT]Re: [EXTERNAL] SONDB bird data for 2021 ORPI project

External Email

Hi again -

Another week got away from me! I was hoping to set up a call with you this week, but my calendar is filling up. Would Monday, Thursday, or Friday next week work for you?

Helen Thomas
Data Manager
National Park Service
[Sonoran Desert Network](#)
(435) 260-9858

From: Flesch, Aaron D - (flesch) <flesch@ag.arizona.edu>
Sent: Monday, January 25, 2021 9:45 AM
To: Thomas, Helen M <Helen_Thomas@nps.gov>
Subject: Re: [EXTERNAL] SONDB bird data for 2021 ORPI project

Sounds great Helen! Look fwd to it.

I'm in the field Thurs and Fri this wk but have decent availability otherwise

regards
Aaron

From: Thomas, Helen M <Helen_Thomas@nps.gov>
Sent: Friday, January 22, 2021 5:54 PM
To: Flesch, Aaron D - (flesch) <flesch@ag.arizona.edu>
Subject: [EXT]Re: [EXTERNAL] SOND bird data for 2021 ORPI project

External Email

Hi, Aaron -

Happy new year! Thanks for the follow-up. I have no idea how it suddenly got to be late January!

Having a discussion is a great idea. I should be able to do that either next week or the following week. I am considering having one of my colleagues join us. I will get back to you early next week, once I've had a chance to touch base with her.

Have a good weekend!

Helen Thomas
Data Manager
National Park Service
[Sonoran Desert Network](#)
(435) 260-9858

From: Flesch, Aaron D - (flesch) <flesch@ag.arizona.edu>
Sent: Wednesday, January 20, 2021 6:08 PM
To: Thomas, Helen M <Helen_Thomas@nps.gov>
Subject: Re: [EXTERNAL] SOND bird data for 2021 ORPI project

Hi Helen

Thanks so much for your note before the holidays. Hope your 2021 is off to a good start! Tough 2020 but hopefully things will start brightening here. The rain is a good start!

I'm prepping for our bird field season in Organ Pipe starting late Feb., and tomorrow, submitting a proposal for work in SAG-E, CHIR, and CORO for what would be bird work in spring-summer 2022

For both efforts we would like to acquire all the point count records for those parks going back as far as you have. For OP, I will be combining that information with data from their EMP and running what I hope are some illuminating analyses on community change (proposal attached).

Can we make a time to discuss the data use agreement etc. and any interest I&M may have in collaborating on our efforts? I'd welcome I&Ms participation in the reporting and any publications we may spin out of the effort, if any of that is of interest (no pressure)

I'd also like to contribute our 2021 data to your database for all the I&M points if you want it.

regards and thanks for your time

Aaron

From: Thomas, Helen M <Helen_Thomas@nps.gov>
Sent: Friday, December 18, 2020 5:28 PM
To: Flesch, Aaron D - (flesch) <flesch@ag.arizona.edu>; Hubbard, Andy <Andy_Hubbard@nps.gov>
Cc: Holm, Peter A <Peter_Holm@nps.gov>
Subject: [EXT]Re: [EXTERNAL] SOND bird data for 2021 ORPI project

External Email

Hi, Aaron -

Nice to meet you as well. I look forward to discussing the data and data use agreement with you early next year.

Happy holidays!

Helen Thomas
Data Manager
National Park Service
[Sonoran Desert Network](#)
(435) 719-2340

From: Flesch, Aaron D - (flesch) <flesch@ag.arizona.edu>
Sent: Friday, December 18, 2020 10:43 AM
To: Hubbard, Andy <Andy_Hubbard@nps.gov>
Cc: Holm, Peter A <Peter_Holm@nps.gov>; Thomas, Helen M <Helen_Thomas@nps.gov>
Subject: Re: [EXTERNAL] SOND bird data for 2021 ORPI project

Thanks Andy! and nice to "meet" you Helen.

Grateful for your willingness to share bird data, and hope our eventual products are useful to the Network.

I hear you Andy on the statistical issues re. formal trend monitoring for occupancy and abundance type populations parameters. Variation in the methods over time in ORPI are another major hurdle!

We will surely confront these issues in 2021, but I am hoping to solve some of them by using multivariate community-based techniques such as those I recently used comparing changes in Sky Island bird communities between the 1930-50s and 2000s (see attached if you're interested). The inferences are more general, but they can provide powerful insights into community trends and drivers.

Beyond ORPI, I'm working on a proposal with Don Swann for SAGE looking at impacts of wild and

prescribed fire on birds, so I'd like to acquire SOND data for those areas as well

We are up against the Holidays here, but I will circle back early in the new year with you Helen to explore and request the use agreement.

My best and happy holidays
Aaron

From: Hubbard, Andy <Andy_Hubbard@nps.gov>
Sent: Wednesday, December 16, 2020 1:39 PM
To: Flesch, Aaron D - (flesch) <flesch@ag.arizona.edu>
Cc: Holm, Peter A <Peter_Holm@nps.gov>; Thomas, Helen M <Helen_Thomas@nps.gov>
Subject: [EXT]Re: [EXTERNAL] SOND bird data for 2021 ORPI project

External Email

Hi Aaron:

Sorry for the delayed response (and thanks for the gentle prod, Peter) - I've been buried here of late.

You are welcome to all of the SODN bird monitoring data for ORPI, and other parks if you are interested - Helen Thomas, SODN Data Manager (copied here) can work with you on identifying specific datasets. We'll need to sign a data use agreement, which I think you've done before.

As you both know, the number and siting of transects sampled at ORPI has varied greatly over time, from the original sites that Tim Tibbetts had surveyed in the 1990s to the IMBRC grids that we tried with FWS and Tucson Audubon near the end of our monitoring period. Beyond design issues, the number and actual locations of sampling were most influenced by safety considerations and access.

Bill Gould (NMSU) analyzed our bird monitoring data across the SODN parks - he concluded that we could not meet our monitoring objectives at the park-scale except possibly at ORPI, and only if we greatly increased our sampling intensity (which we cannot afford with a flat monitoring budget). This affirmed what Dave Pavlaki at RMBO had previously concluded and led the SODN Technical Committee to replace bird monitoring with terrestrial mammal monitoring in 2016. The Chihuahuan Desert Network continued trying to tweak the bird protocol to meet any of the objectives and has been working with Bob Gitzen (Auburn) on pretty much the same questions as Pavlaki and Gould had looked at. I've attached Bill's final report, and I can get you in touch with the Auburn and CHDN folks if you are interested in their efforts.

Hope you are doing well, Aaron!

Best,

Andy

Andy Hubbard

Program Manager, National Park Service - Sonoran Desert Network

Desert Research Learning Center
12661 E. Broadway Blvd.
Tucson, AZ 85748

520-429-8147

<https://www.nps.gov/im/sodn/index.htm>

<https://www.nps.gov/im/sodn/drlc.htm>

From: Flesch, Aaron D - (flesch) <flesch@ag.arizona.edu>
Sent: Wednesday, November 18, 2020 1:22 PM
To: Hubbard, Andy <Andy_Hubbard@nps.gov>
Cc: Holm, Peter A <Peter_Holm@nps.gov>
Subject: [EXTERNAL] SOND bird data for 2021 ORPI project

This email has been received from outside of DOI - Use caution before clicking on links, opening attachments, or responding.
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Hi Andy

Hope my note finds you well. It's been a while since we've interacted, and it's nice to have a reason to reach out and connect with you again.

I have a funded bird project in OPCNM this coming field season that involves using past survey data to assess changes in populations and communities, address some of the drivers of changes, and synthesize past data from a variety of methods to do so. We will also be working in Pinacate to link up cross-border efforts and on some special status species surveys. Our proposal is attached

Our budget is limited but the work load and opportunities are big given all the past work and methods going back to the early 90's. We will have some survey help from Danny Martin, and Peter of course is helping a ton with logistics, past data, veg and weather data, and a ton of other things.

I am reaching out to you to both coordinate our efforts and plans with the Networks, and to request data and spatial info from SOND's past work and points in OP. I was your contractor in 2008 and we ran a 3-5 transects in OP if I remember, but pretty sure we did not assess or compare with past data or estimate trends etc. Have any of this field or office work been done since 2008? If so and you can send reports they would be helpful

It would also be useful to assess what plans and resources SOND have to work with these and other data in OP in the future, to synergize our efforts. If something we plan to do is on your agenda, and we can coordinate that, I'd be thrilled.

regards and let me know if you want to chat sometime about this or other projects.
Aaron

Aaron D. Flesch, Ph.D.
Research Scientist
School of Natural Resources and the Environment
University of Arizona
The Desert Laboratory - Tumamoc Hill
1675 W. Anklam Road
Tucson Arizona 85745
Phone: 520-730-4656
email: flesch@email.arizona.edu
Web: www.aaronflesch.com
[Google Scholar](#)
[Research Gate](#)

Appendix C: Article published by project staff in CEDO's online newsletter on this project and importance of bird monitoring.



Blog Post

CEDO's Blog > Partners > **Monitoring the pulse of the desert through avian monitoring in the Pinacate Biosphere Reserve**



Monitoring the pulse of the desert through avian monitoring in the Pinacate Biosphere Reserve

by Aaron Flesch July 31, 2021

BIODIVERSITY, CEDO, DESERT, ECOLOGICAL MONITORING, PARTNERS  0

By: Aaron Flesch, Miguel Grageda García

Monitoring the status and distribution of wildlife and vegetation are fundamental aspects of conservation and sustainable management of biodiversity and natural resources. Without solid baseline information on these and other parameters, individuals, habitats, and potentially entire populations or species can be lost before they are documented and protected. When properly designed, ecological monitoring efforts can help trigger focused management and protection actions needed to ensure that species and resources persist

for the enjoyment of future generations, to ensure essential ecological functions and ecosystem services, and for their own intrinsic and inherent values.

Ecological monitoring is especially important in regions that face the gravest threats from climate and land-use change and other stressors, which include arid regions. These stressors could have especially severe and compounding impacts on wildlife and habitats in arid environments because resources are often limited, weather events are often unpredictable, and small changes in precipitation and temperature can have major effects on abundance and vital rates of species that are often living near ecological tolerance limits. In fact, a century of monitoring in the Mohave Desert of North America shows the virtual collapse of bird communities over this period due to climate change, even in a protected area (see A, B).



Figure 1: View northwest from the northern high point in the Pinacate high peaks region showing cinder cones emerging from the volcanic shield and in the distance the dunes of Gran Desierto.

The **El Pinacate and Gran Desierto de Altar Biosphere Reserve** is a **UNESCO World Heritage Site** managed by the federal government of Mexico occupies a hyperarid region of the central Sonoran Desert and is a place of exceptional natural beauty and biodiversity. The eastern portion of El Pinacate that is the subject of our efforts is dominated by a massive, dormant volcanic shield and an immense area of sand dunes that form the largest dune network in North America. It includes a small shield-type volcano, reaches elevations of ~1,200 m above sea level just north of the coast of the Gulf of California, extensive black and red lava flows, hundreds of cinder cones of all shapes and sizes, and 10 enormous and almost perfectly circular Maar craters, which are formed by steam explosions as a result of magma superheating underground water (Figure 1). Such a rich and complex geological history and broad elevation gradients have helped create a multitude of wildlife habitats and promoted high biodiversity and conservation value.

Importantly, El Pinacate is also in **CEDO Intercultural's** "backyard", which makes it a valuable setting for ecological study, environmental education, and local efforts to protect resources and promote sustainable uses of Sonoran Desert environments for the human communities that depend on them. In Mexico, lands that comprise Natural Protected Areas such as El Pinacate are often owned by individual people or communally in the form of ejidos, rather than by the federal government as in the U.S. Thus, sustainable use of natural resources within protected areas is fundamental for conservation. Such arrangements make environmental education and development and demonstration of sustainable management practices, essential for the protection and enhancement of natural resources, which highlights an important role of CEDO in the region.

In 2021, we began a partnership between the **University of Arizona's School of Natural Resources and the Environment**, **CEDO**, the **National Commission of Natural Protected Areas in Mexico (CONANP)**, and the **U.S. National Park Service (NPS)**. Our efforts, funded by **NPS' Southwest Resources Border Protection Program**, focused on:

1. Ecological monitoring of bird communities in El Pinacate,
2. Linking monitoring with similar efforts in Organ Pipe Cactus National Monument in neighboring Arizona that began in the early 1980s, and
3. Educating local people in Mexico in the region surrounding the reserve about the ecology of Sonoran Desert environments, local bird communities, and how they can contribute to conservation.

Birds are an important focal group for monitoring because each individual species is linked to a broad array of specific resources and conditions on which they depend, because they can be surveyed more efficiently than other vertebrate groups, and because birds have broad economic value and appeal to the public. Here, we summarize our efforts, review some preliminary findings from analyses that are still ongoing, and discuss future activities for the CEDO community.

Over three past years (2015-2017), then CONANP staff biologist at El Pinacate, **Miguel Grageda García** established up to eight transects and conducted point counts for birds. Transects were initially established in areas with representative habitats for the birds across the reserve and in significant natural areas. These efforts provide some initial baseline data and spanned the Agua Dulce reach of the Río Sonoyta that supports the only free-flowing perennial water in the El Pinacate region, areas near Papago Well where natural hard-rock tanks or tinajas support surface water and riparian woodlands, and areas of dense saguaros, sand dunes, desert scrub and other resources. Efforts in 2021 added two new transects and the authors and CEDO staff completed two to three visits to complete point counts between February and May. Moreover, we also surveyed special status species such as Golden Eagle and Prairie Falcon across the El Pinacate shield. In this region, most raptors including both of these species depend on sheltered, often north-facing cliffs to place nests that are rare and distributed locally in El Pinacate. Hence, surveys for these species focused on large craters and on significant cinder cones that harbored cliff faces.

Over four years of effort, we detected approximately **84 species of birds** across the 10 transects during point counts, and several additional species incidentally or during surveys efforts for special status species. In 2021, we observed 70 species during point counts and found that species richness (e.g., total number of species) was highest (40-45 species) along the Río Sonoyta and near Papago Well, which is not surprising given these are the only areas in El Pinacate where surface water is typically found. Richness was lowest (12-15 species) in desertscrub on the east side of Pinacate Peak and on sand dunes, which support habitats of lower structural diversity. Nonetheless, several species of conservation interest including **LeConte's Thrasher** and **Sagebrush Sparrow** were observed on dunes making these areas significant for bird communities.



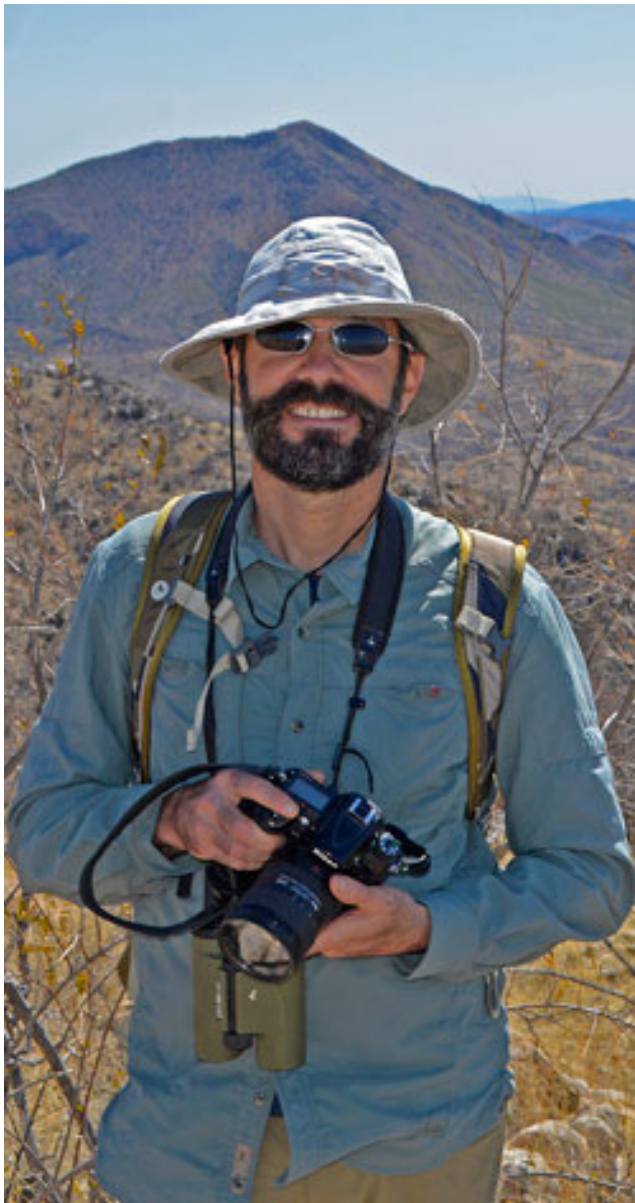
Figure 2: Field training lead by University of Arizona staff attended by CEDO and CONANP staff and collaborators in the dunes region of El Pinacate.

During survey efforts for special status species, we observed **evidence of nesting by Prairie Falcon** on cliffs at two large Maar craters and observed a sub-adult **Golden Eagle**, which could have been a migrant or breeder, at one large Maar crater. Numerous nests of **Red-tailed Hawk** and **Great Horned Owl** were observed at the more than 15 cinder cones we surveyed, and were often using cliff faces. Importantly during and just before the 2021 field season, we also helped train CEDO staff and collaborators in field methods for this work and in bird identification (Figure 2). Ongoing efforts will compare baseline data from earlier years with results of the 2021 field season, and provide all data to CEDO and CONANP for future applications.



Environmental education efforts linked to our project are also still ongoing and curricula are now being developed by CEDO staff that will be implemented this fall and winter. Initial education efforts included a kickoff event at El Pinacate in mid-February 2021 that was attended by approximately 25 people including numerous children and young adults (Figure 3). During this event, we gave presentations on bird communities and habitats in El Pinacate, and on field methods for avian ecology. Field methods were then implemented by University of Arizona and CEDO biologists during field work.

Our efforts represent a multifaceted approach to ecological monitoring and environmental education in support of landscape conservation and sustainable use of natural resources in an important biodiversity hotspot in northwest Mexico. Collaborative efforts between local non-governmental organizations such as CEDO working together with researchers, local people, and government management agencies are essential for realizing landscape conservation across broad areas. It is our hope that further integrating monitoring efforts across this binational landscape will help foster conservation and sustainable management of what is one of the largest protected areas in North America, and the crown-jewel of more than a century of binational conservation efforts in the U.S.-Mexico borderlands.



About the Author:

Aaron D. Flesch, Ph.D.

Ph.D. – Organismal Biology and Ecology

– **2013**, Division of Biological Sciences,

University of Montana, Missoula, MT.

Advisor: Richard Hutto.

M.S. – Wildlife Biology – 2003, School of

Natural Resources and the Environment,

University of Arizona, Tucson, AZ. Advisor:

Robert Steidl.

B.A. – Environmental Studies – 1995,

Prescott College, Prescott, AZ. Advisor:

Walt Anderson.

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Last Name * (required)

Appendix D: Article published by retired U.S. Fish and Wildlife Service biologist and CEDO volunteer Mark Kaib in CEDO's online newsletter about his experiences working with CEDO and project staff.



Blog Post

CEDO's Blog > Stories > **Letter from a CEDO Friend**



Letter from a CEDO Friend

by Mark Kaib March 31, 2021

BIODIVERSITY, CEDO, FRIENDS & FAMILY, STORIES, STORIES  1

By: Mark Kaib. Retired USFWS Wildfire Ecologist

Dear Friends,

I had a special experience at **CEDO** in Puerto Peñasco recently. Having traveled since childhood to these wonderful tide pools and beaches, I was always a **supporter of CEDO** since its beginning. My interest was to go back and rekindle some old memories and to **volunteer for CEDO**. Dr. Nélida Barajas Acosta, CEDO's relatively new Executive Director, and the awesome staff at CEDO are very impressive. They welcomed me like familia. Right away we went out camping and conducting bird surveys at the under-appreciated **Pinacate National Park and Biosphere Reserve**. Then we did ecotours at the **Morua Estuary** on kayaks with a visit to the **Women's Oyster Farm and Cooperative**. What's next ? Hasta mañana would tell.... An educational interchange to develop trust and more sustainable fishing technologies and practices with the Peñasco white-clam diver's cooperative... or a ^

community meeting in Santa Clara to discuss endangered Vaquita porpoise protection, or a workshop in Bahia San Jorge with the blue swimming crab cooperative. Truly amazing... It was also very nice on some days to stay and relax at CEDO's Casa Blanca, and help Zaida and Paloma with organizing the **gift shop**, with museum tours, or science collections.



Camping in 1970 on Sandy Beach with the Kaib family (Photo: John R. Kaib)

Every day was an amazing! new experience. I am a world traveler, and have been going to Central America lately as an alternative to Mexico. This trip brought me back to the Mexico that I knew. The generous hospitality of the CEDO staff and Mexicans in general, their strong sense of family and place, incredible food, and enormous landscapes with abundant and diverse wildlife.... I have a new rekindled compassion and hope for the future of Mexico and her conservation. Much of this comes from seeing what novel projects CEDO continues to accomplish and building on their **40+ years of community empowerment for conservation**. Remarkably this is all done on a shoestring only because of their strong^

devotion to the work.

Nélida and her staff (**BTW! mostly women**), are leading the way for conservation on several very impressive fronts. She and her family and everyone at CEDO were generous and humble, and enlightened me during my 3 week internship.

They are very professional, driven by conservation ethics, and ambitious. I am still in awe at the breadth and diversity of the very important conservation portfolio they have developed. I want to thank them for sharing a small part of their world it was truly inspiring.

None of these efforts could be fulfilled without our support. **This is a very crucial time for CEDO and Puerto Penasco.** They are just beginning to crawl back from the virus pandemic. Sprawling resort developments do not sleep however, endangered fisheries are being further depleted, and there are emerging threats to important wildlife habitats.

CEDO has always understood, the foundational conservation work is at the community scale, fortifying their traditional lifeways and resilience. **CEDO works on all these dimensions of conservation through education, training, science applications and community action! The result is a long history of success stories.**











A recent trip to Pinacate to establish bird diversity monitoring transects was educational for me. Under the leadership of Miguel Angel Grageda, U of A graduate student, Dr. Aaron Flesch, and Angeles Sánchez Cruz at CEDO, a binational meeting was convened to begin this important international conservation collaboration at the new Pinacate Visitor Center. After introductions, protocols and getting connected we proceeded out to the sand-dune landscape towards the Sea of Cortez to fill our eyes and noses and minds with sand. Fortunately the winds on our first night were mild and the camp fire, modelo negra and new friends made for nice company.

We were up before dawn, some dark strong coffee, burritos, and the team launched to establish the first transect across the vast dune fields also known as the Gran Desierto. The end of the transect was so close.... but we could not yet see the blue ocean. So of course we had to climb the highest nearby dune and be rewarded by a similar view that **Padre Kino had some 400 years ago**, of the Sea of Cortez in all its majesty.

The next morning I found myself out with Aaron and Abelardo. Aaron is an accomplished ornithologist, who risks his life documenting bird migrations across the southwest borderlands. Abelardo is CEDO's professional photographer and interdisciplinary planner. We found ourselves at Campo Cono Rojo, an ancient volcanic cinder cone. We had camped the night before on the lava. We awoke to a dense ocotillo forest with stands of giant *Bursua microphylla*, also known as elephant trees, and fields of medusa-head barrel[^]

cacti. This peculiar and enticing volcanic-scrub forest, you won't find anywhere else in the world but at Pinacate.

The paleo-volcanic desert landscape was very awesome, I expected dinosaurs but was however delighted by zebra-tailed sand lizards, tiny unseen Anna's humming birds, with their high-pitched sirens whizzing by, and the ghost black phainopepla grazing on paloverde mistle toe berries. I was again delightfully reconnected to mother earth.

This was and is a great time to **get inspired by CEDO for our Planet. Donations always help. Volunteering** for a few weeks or months can be extremely rewarding, and a nice chance to brush up on your Spanish. I have to encourage anyone that cares... **Please continue to generously support CEDO and conservation any way you can.** Keep an eye out for the CEDO's ever-changing wish list, there may be an item that is collecting dust in your garage that would be a great benefit to their operations. Having gringo volunteers, provides a different dimension of support to CEDO that is invaluable to everyone. You can even possibly work from the USA remotely. There are an endless number of projects, chores, maintenance, education, citizen science, training, and ways to personalize your experience based on your knowledge, skills, and interest. **The intercultural synergy created during these volunteer exchanges is invaluable.**

I was living my dream the past 3 weeks, and personally benefited way more than CEDO did from my visit. Please consider more deliberate donations to CEDO and wildlife conservation, or through a volunteer intercultural experience with CEDO... you won't regret it.

Another Day – More Adventure

Mark Kaib | Retired USFWS Wildfire Ecologist

Support CEDO

Our equipment, our field station, and our facilities are fundamental for our research, conservation, and community well-being work.



Support CEDO's efforts to continue our field work to protect and promote the responsible use of this wonderful ecoregion where the Sonoran Desert meets the Sea of Cortez.



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About the Author:

John Mark Kaib

Retired USFWS Wildfire Ecologist.

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Appendix E: Description of study sites, differences in observed species richness across time, and lists of species and total detections during each year of effort including 2015-2017 in Pinacate Biosphere Reserve written by project staff member Miguel Grajeda

Bird surveys in the Pinacate Biosphere Reserve, 2021

The Pinacate Biosphere Reserve is an area considered as an AICA or IBA No. 124, which is an international standard for an Important Bird and Biodiversity Area. This Reserve has the category Mex-1 (Mexico 1999), which means that the area has at least one population of a species considered as threatened, in danger of extinction or vulnerable (NOM-ECOL, CIPAMEX) (Arizmendi y Marquez, 2001). There is a list of 222 species of birds for this area according to its Management Plan (SANPES, 1994).

We decided to conduct point count surveys in sites where the Biosphere Reserve has done it before in order to compare the results obtained this year 2021. The first bird surveys were done during the years 2015, 2016 and 2017. Later, no surveys were conducted in 2018, 2019 and 2020 until now.

Thus, point count surveys were done in the 8 transects that already existed and two more were established in areas that haven't been surveyed before like the sand dunes and the high part of the Pinacate volcano. Each transect was originally established in areas with representative habitats for the birds within the Reserve. In this way, we may increase the probability of finding species that are attracted to a specific type of habitat. The description of each one of the transects are shown in Table 1.

Table 1. Description of each one of the 10 transects established for bird surveys in the Pinacate Biosphere Reserve. Elevation range within the transect and number of point count stations within each transect during the surveys of the year 2021.

Transect	Habitat	Elevation (meters)	Number of point count stations	No. of visits	Date range in 2021
Cono rojo	High elevation (>400m) in the Pinacate volcano, with presence of lava flows and desert shrubs	408-436	10	1	
Sand dunes	Sand dunes with halophytic vegetation.	75-140	8	2	
Sierra Blanca	Foothills of an igneous rock mountain with washes and desert vegetation.	65-77	10	2	

Estacion	Ephemeral river with desert shrubs on the shore.	129-140	10	2	
Batamote Mt.	Mountain with desert vegetation	142-262	10	2	
Pastizal (Grassland)	Plain with short grassland.	128-144	10	2	
Agua Dulce	Perennial river and riparian vegetation.	310-322	5	2	
Papagos wash	Wash with high desert trees and shrubs.	198-208	10	1	
Playa Diaz	Desert grassland with saguaro cactus.	200-209	10	2	
Elegante crater	Volcanic area with high vertical cliffs. Desert shrubs.	284-292	10	2	

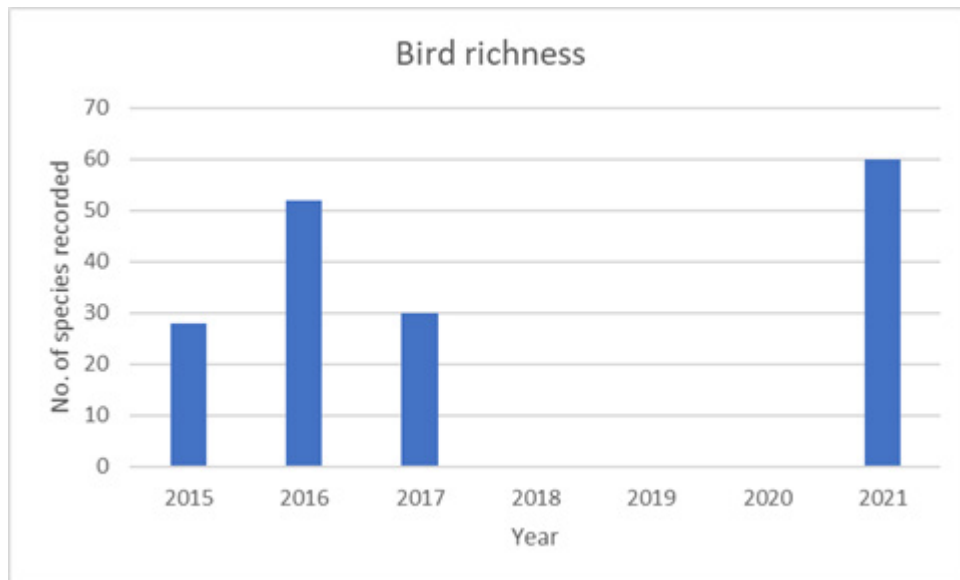
For this year, two more transects were added to the survey effort and also 5 more stations were added to each existing transects, increasing twice the number of stations but reducing the survey time on each from 10 to 8 minutes.

Table. Effort of surveys in 2021 compared to previous years.

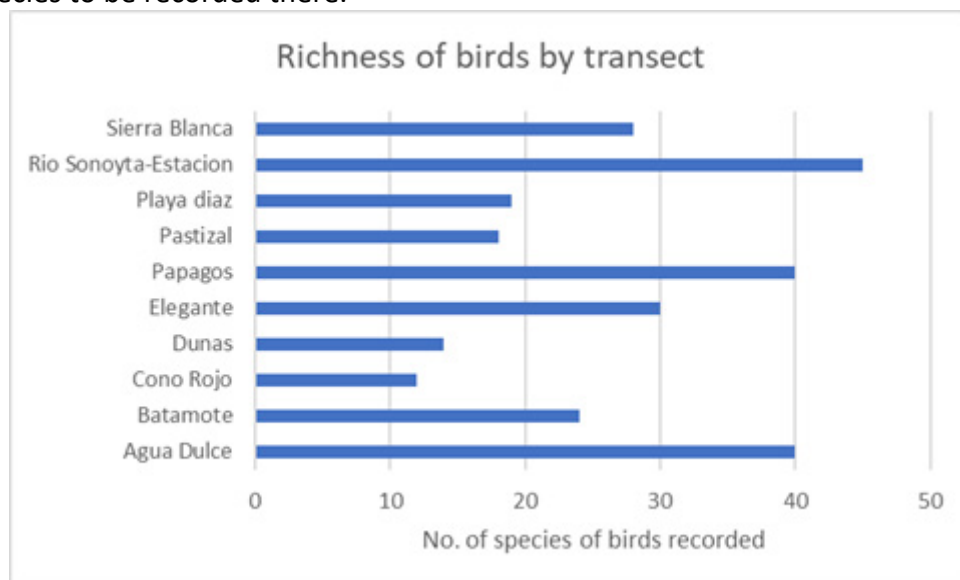
	2015	2016	2017	2021
Transects	6	8	7	10
Stations	30 st (1 round)	35(1st round) +30(2nd round)= 65 st	35 st (1 round)	93 (1st round)+72(2nd round)=165 st
No. minutes	(10 min/station) 300 min	(10 min/station) 650 min	(10 min/station) 350 min	(8 min/station) 1,320 min

Results

Thus, after comparing the results obtained during the bird surveys of 2021 with previous years we obtained the highest richness for this year with a total of 60 species. Increasing the bird list for the bird survey effort to 84 species (Appendix I).



The transect with the highest number of species detected was Rio Sonoyta-Estacion with 45, the transect in Agua Dulce and Papagos wash are the second richest with 40 species each. On the other hand, sand dunes and Cono Rojo are the transects with the lowest richness of all. Although, these two transects were marked this year, so they still have potential for more species to be recorded there.

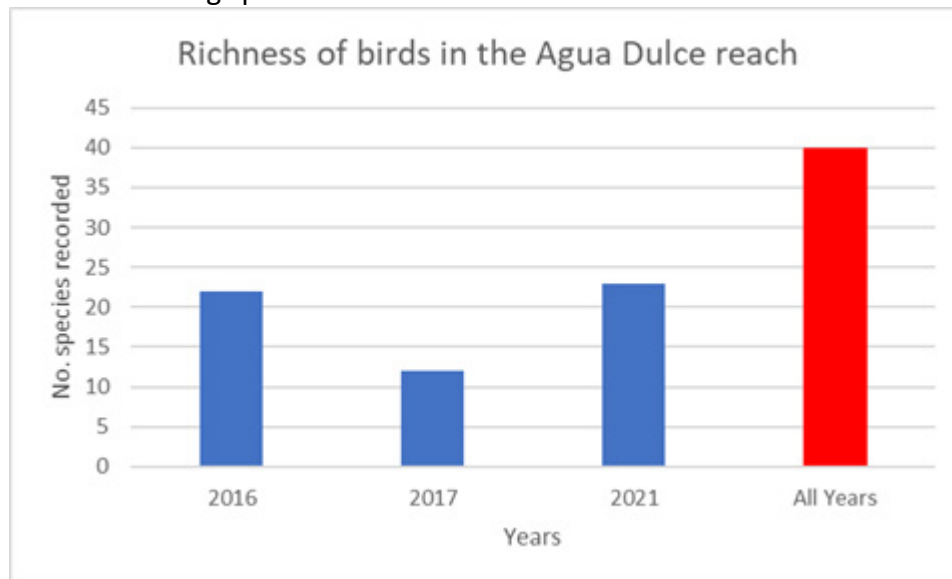


1. Agua Dulce reach

The Agua Dulce reach is the only area with perennial availability of water in the whole Pinacate region and presence of fish and aquatic turtles. This is a segment of the Sonoyta river which keeps a continuous flow most part of the year, except during the dry season when the water will be found perennial water during the whole year, but only in an area of 1 mile. After that the flow goes underground.

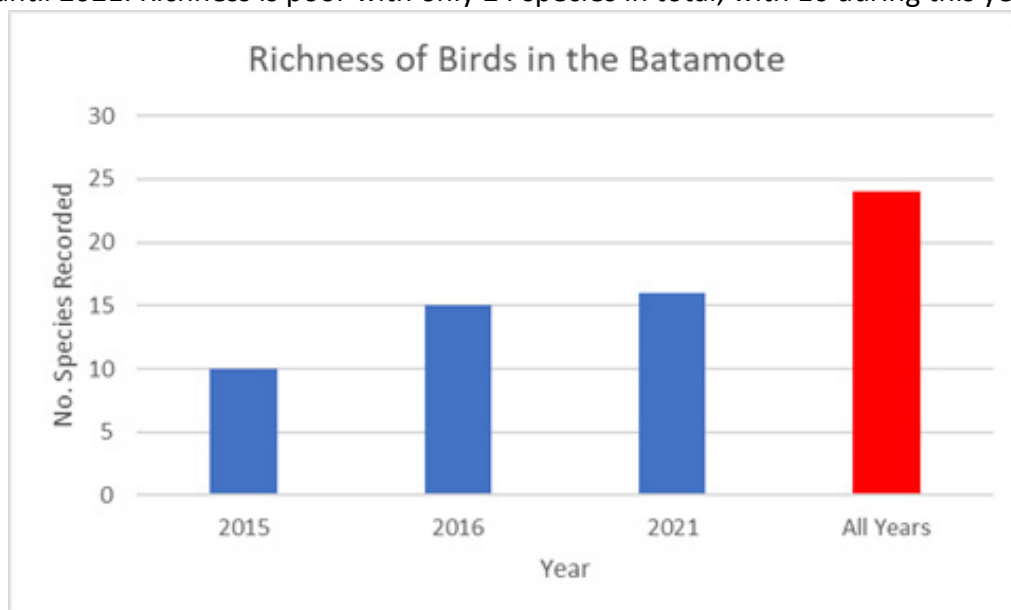
For this area we had a list of 40 species of birds, after an effort of 3 years. 2016, 2017 and 2021. For 2021 we had a total of 23 different species, more than 2016 with 22 and 2017

with only 12. In this area we found the highest concentration of species of birds among all the sites surveyed, which may be due to the perennial water source that can be found in the river. There are some aquatic birds that have been recorded only here like the Belted kingfisher, Killdeer, White fronted ibis, the White egret or the Sora. The species that was most recorded is the Song sparrow with 10 records in 2021 and 13 in 2016.



2. Batamote Mountain

The Batamote trail was situated from the base to the top of the Batamote mountain on the East side of the Pinacate Reserve. This mountain is dominated by desert scrub, and most of it is conformed by exposed rocks. This transect was surveyed in 2015 and 2016, and then again until 2021. Richness is poor with only 24 species in total, with 16 during this year.

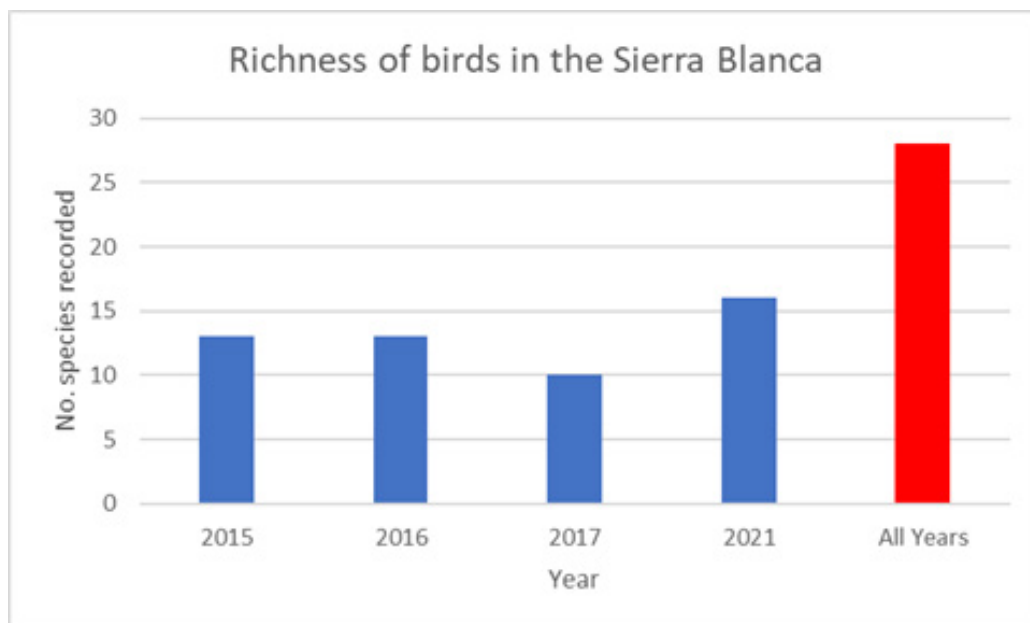




3. Sierra Blanca

The Sierra Blanca trail goes along the base of this ancient mountain range, which has a white coloration due to the granite material. Vegetation in this area is mainly ocotillo and hinds nightshade (*Solanum hindsianum*) growing in washes, which attracts hummingbirds.

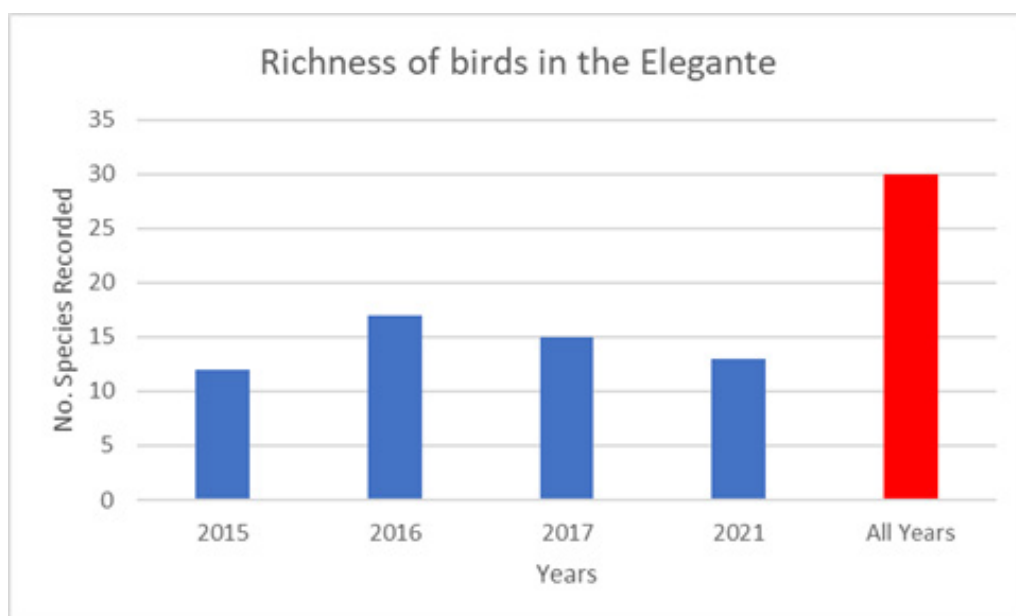
The richness of birds in this area after 4 years of survey is 28 species, with 16 in 2021, 13 in 2015 and 2016 and only 10 in 2017.





4. Elegante crater

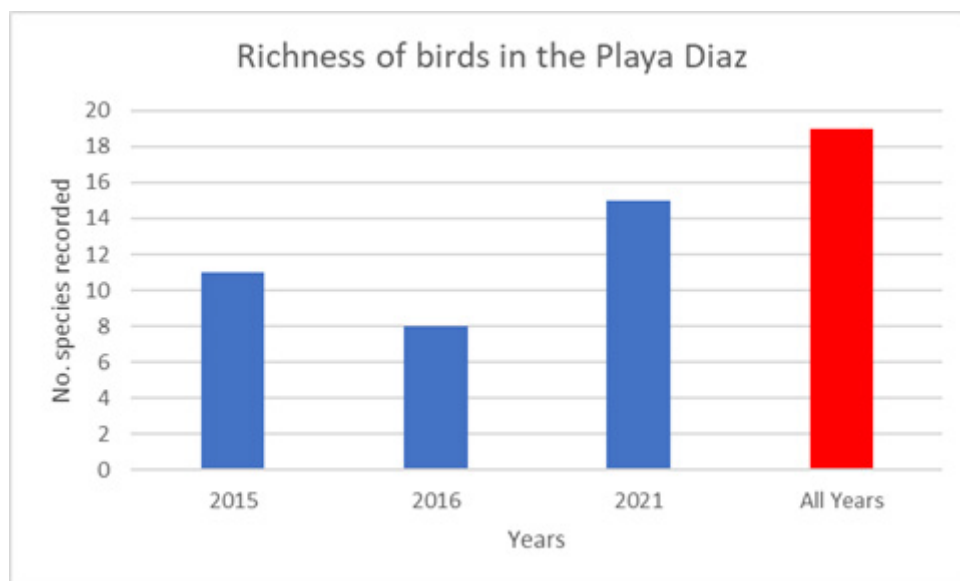
The elegante crater is located in the central part of the Reserve. The trail used to go from the base of the crater to the rim, but this year it was moved along the Elegante crater's rim. This change was done in order to increase the probabilities of detecting raptors inside of the crater. In total, for the last 4 years of survey, we have found a total of 30 species of birds, although, during 2021 we only found 13 species; less than in 2016 and 2017 when we found 17 and 15, respectively.





5. Playa Diaz

This trail was established in 2015 near an area known as Playa Diaz within the Pinacate Reserve. The trail goes through a valley with a presence of sahuaro and the ground is covered with patches of galleta grass (*Pleuraphis jamesii*). In three years of survey a total of 19 species has been recorded. During this year 2021, 16 species were counted here.

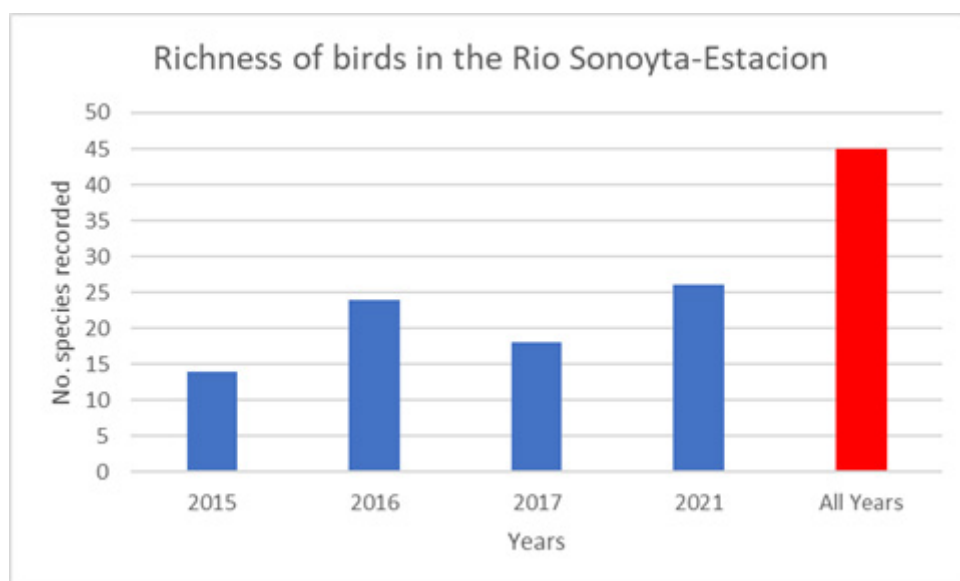




6. Rio Sonoyta-Estacion

This trail was established near the Biological Station of the Pinacate Reserve and it goes along the Sonoyta river, but in a different segment that rarely has water flowing, which lasts only a few days after the rain. So, conditions are different from Agua Dulce reach.

Still, richness was high compared to most of the other transects. After four years of surveys, a total of 45 species have been recorded. In 2021 a total of 26 species were recorded, more than previous years.

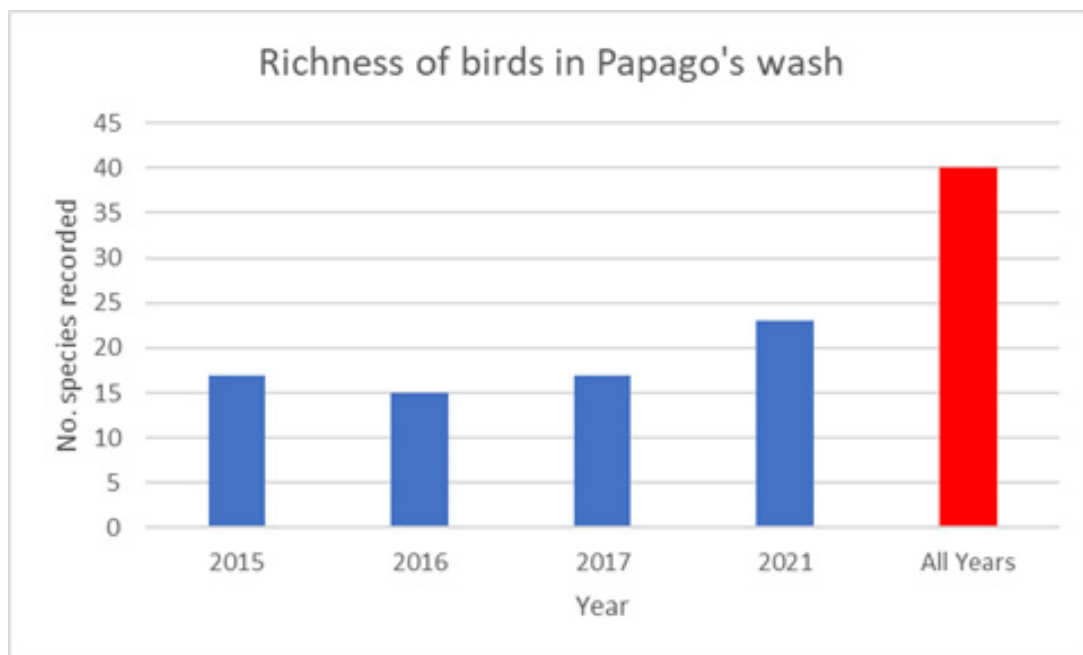


7. Papago's wash

This trail begins in a place known as Papago's tinaja and keeps following a wash that is covered by high mezquite, iron wood and palo verde trees. This wash has a water flow

during the rain event and a few hours afterward. Still, vegetation along the wash is dense and seems to be good habitat for native species of birds.

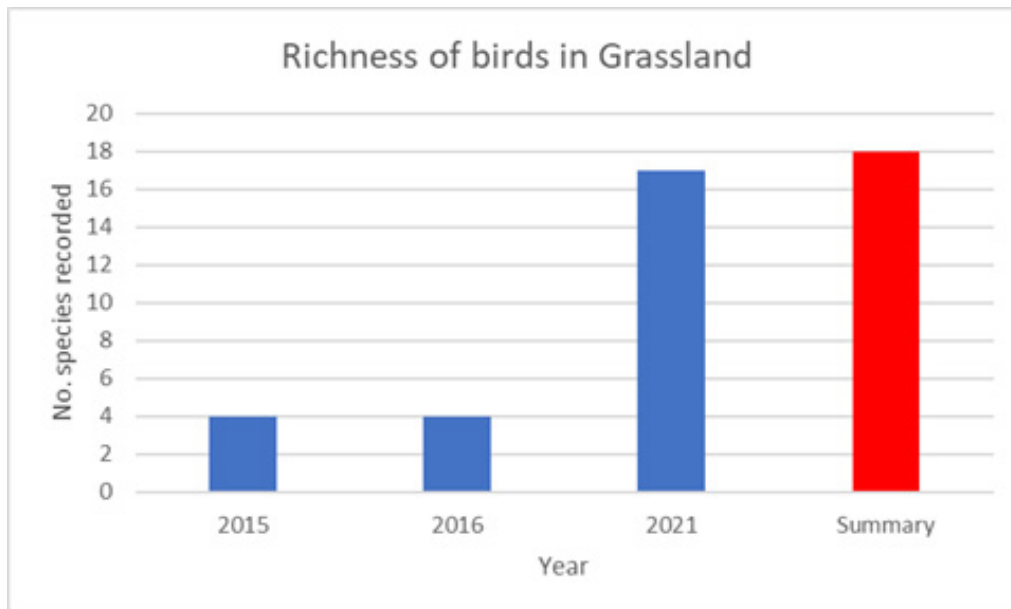
After four years of surveys a total of 40 species of birds has been recorded in this transect. During this year more species of birds were detected (23) than in previous years.



8. Pastizal (Grassland)

This area is an open grassland covered by species like annual threeawn (*Aristida* sp.) grass and plantago (*Plantago* sp.). This is a very changing area, since the temporary and low vegetation cover depends on the amount of precipitation that has occurred previously (weeks or months before). So it may have 60% of vegetation cover one year and as low as 1% in another year.

Richness of birds is also changing in this place and may be related to vegetation cover, since this year we found 17 species, different to the 4 species that were recorded in 2015 and 2016.



9. Sand dunes

This is the first time that this transect has been conducted, so there is no data for comparison. During this year of 2021 a total of 14 species were recorded.

A species of special concern that has been recorded here is the LeConte's thrasher, a bird that has a concern score of 17 according to the U.S. partners in flight rate and it is also considered within the Red Watch List.



10. Cono Rojo

This is the first time that this transect has been conducted, so there is no data for comparison. During this year of 2021 a total of 12 species were recorded.



Discussion

Even when we compared the results obtained for each year, we cannot assume any increase or decrease on the actual number of species detected since the effort time for 2021 was four times higher and the number of habitats evaluated has also increased. Still, the richness of each site can provide useful information on which areas and/or habitats are considered more attractive for birds.

Also, we can have a better idea on the distribution of each species in the Reserve according to the type of habitat that it is using.

We suggest that more intensive survey efforts be established in the Reserve to study different species of birds and their habitats in the long term and to study how their ranges may change through the year.

Also, specific surveys may be conducted to assess the population of threatened species such as the LeConte's thrasher in the sand dunes, golden eagle in craters and cliffs, and mountain plover in areas with short grassland.

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Appendix I

Species recorded by year and number of independent records in the Pinacate Biosphere Reserve.

Species	2015	2016	2017	2021
<i>Accipiter cooperii</i>		1		1
<i>Actitis macularius</i>		1		3
<i>Amphispiza belli</i>		1		
<i>Amphispiza bilineata</i>	12	8	5	20
<i>Ardea alba</i>				1
<i>Athene cunicularia</i>				1
<i>Auriparus flaviceps</i>	18	21	23	21
<i>Bubo virginianus</i>				1
<i>Buteo jamaicensis</i>	4	9		9
<i>Butorides virescens</i>		1		
<i>Calamospiza melanocorys</i>		2		
<i>Callipepla gambelii</i>	21	14	21	9
<i>Calypte anna</i>				19
<i>Calypte costae</i>		3	3	40
<i>Campylorhynchus brunneicapillus</i>	36	15	16	61

<i>Cathartes aura</i>	5	12	8	19
<i>Catharus guttatus</i>		3		
<i>Catherpes mexicanus</i>	7	5		3
<i>Charadrius vociferus</i>				9
<i>Chordeiles acutipennis</i>	4	2	3	1
<i>Circus cyaneus</i>		1		2
<i>Colaptes chrysoides</i>	2	2		12
<i>Coragyps atratus</i>				1
<i>Corvus corax</i>	5	6	1	18
<i>Dryobates scalaris</i>		3		4
<i>Egretta thula</i>	1			
<i>Empidonax difficilis</i>				1
<i>Eremophila alpestris</i>	4	2		
<i>Falco mexicanus</i>	1	2		
<i>Falco peregrinus</i>				1
<i>Falco sparverius</i>	2			1
<i>Geococcyx californianus</i>	3	1		1

<i>Haemorrhous mexicanus</i>	3	16	3	28
<i>Icterus bullockii</i>		1	3	
<i>Lanius ludovicianus</i>	16	3	5	19
<i>Lymnocryptes minimus</i>				1
<i>Megasceryle alcyon</i>				2
<i>Melanerpes uropygialis</i>	21	22	26	21
<i>Melospiza lincolnii</i>		1		
<i>Melospiza melodia</i>		13		10
<i>Mimus polyglottos</i>			12	5
<i>Mniotilta varia</i>		1		
<i>Molothrus ater</i>	3			1
<i>Myiarchus cinerascens</i>	10	3	8	25
<i>Oreothlypis luciae</i>		1		2
<i>Parabuteo unicinctus</i>				3
<i>Petrochelidon pyrrhonota</i>			1	11
<i>Phainopepla nitens</i>		11	15	9
<i>Pheucticus melanocephalus</i>	1	5	1	

<i>Piranga ludoviciana</i>	3	2		
<i>Plegadis chihi</i>				1
<i>Polioptila caerulea</i>				1
<i>Polioptila melanura</i>	8	11	8	11
<i>Pooecetes gramineus</i>		1		
<i>Porzana carolina</i>				1
<i>Quiscalus mexicanus</i>		1		
<i>Regulus calendula</i>		7	1	1
<i>Salpinctes obsoletus</i>	4	2	6	10
<i>Sayornis nigricans</i>		6	1	1
<i>Sayornis saya</i>		2		12
<i>Selasphorus rufus</i>				2
<i>Setophaga nigrescens</i>		5		
<i>Setophaga petechia</i>		6	2	7
<i>Setophaga pityophila</i>				1
<i>Sialia currucoides</i>				1
<i>Spizella pallida</i>		7		

<i>Spizella passerina</i>				1
<i>Streptopelia decaocto</i>			2	
<i>Sturnella neglecta</i>				1
<i>Tachycineta bicolor</i>				6
<i>Tangara ludoviciana</i>			1	
<i>Thryomanes bewickii</i>		1		
<i>Toxostoma crissale</i>	1			
<i>Toxostoma curvirostre</i>		3	9	20
<i>Toxostoma lecontei</i>		2		
<i>Tyrannus verticalis</i>		6	2	8
<i>Tyto alba</i>			1	
<i>Vireo gilvus</i>		2		1
<i>Vireo olivaceus</i>			1	
<i>Wilsonia pusilla</i>				2
<i>Xanthocephalus xanthocephalus</i>	1			
<i>Zenaida asiatica</i>	8	10	18	20
<i>Zenaida macroura</i>	12	10	38	42

<i>Zonotrichia leucophrys</i>		5		13
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Appendix II

Species recorded by transect in the Pinacate Biosphere Reserve in 2021.

Row Labels	Agua Dulce	Batamote	Cono Rojo	Dunas	Elegante	Papagos	Pastizal	Playa diaz	R.Sonoyta-Estacion	Sierra Blanca	Grand Total
<i>Accipiter cooperii</i>	1										1
<i>Actitis macularius</i>	3										3
<i>Amphispiza belli</i>				1							1
<i>Amphispiza bilineata</i>		5	8	2				3	1		19
<i>Ardea alba</i>	1										1
Ardeidae	1										1
<i>Athene cunicularia</i>							1				1
<i>Auriparus flaviceps</i>			5	1		4				3	13
<i>Bubo virginianus</i>						1					1
<i>Buteo jamaicensis</i>				2			1	4	1	1	9
<i>Calypte anna</i>					12				4	4	20
<i>Calypte costae</i>	2	8	11			5			4	10	40
<i>Callipepla gambelii</i>	2				3	1	2		3		11
<i>Campylorhynchus brunneicapillus</i>	2	1	5			1		51	1		61
<i>Cathartes aura</i>	5	3		1	1	2	2	2	1	2	19
<i>Catherpes mexicanus</i>		3									3
<i>Charadrius vociferus</i>	8						1				9
<i>Chordeiles acutipennis</i>				1							1

<i>Circus cyaneus</i>				1			1				2
<i>Colaptes chrysoides</i>			1					11			12
<i>Coragyps atratus</i>	1										1
<i>Corvus corax</i>	1	1		4	8	1	1		3	3	22
Emberizidae							1				1
Emberizidae				1				1	1	2	5
<i>Empidonax difficilis</i>					1						1
<i>Empidonax sp</i>									1		1
<i>Falco peregrinus</i>										1	1
<i>Falco sparverius</i>								1			1
Gal del	1										1
<i>Geococcyx californianus</i>						1					1
<i>Haemorhous mexicanus</i>	1	4	9	2	5	2	3		4	1	31
<i>Hirundo rustica</i>					1						1
<i>Lanius ludovicianus</i>		2	1		1		7	1	6	2	20
Lei luc						1					1
<i>Megasceryle alcyon</i>	2										2
<i>Melospiza melodia</i>	12										12
<i>Melanerpes uropygialis</i>	6	1	5			1		3	2		18
<i>Mimus polyglottos</i>		1		1				3			5
<i>Molothrus ater</i>							1				1
<i>Myiarchus cinerascens</i>			11			11			2	1	25
No bird		1		1			4				6

<i>Oreothlypis luciae</i>						1					1
<i>Parabuteo unicinctus</i>	3										3
<i>Petrochelidon pyrrhonota</i>	7			1				3			11
<i>Phainopepla nitens</i>	4		2			2			1		9
<i>Dryobates scalaris</i>					6	1	1				8
<i>Plegadis chihi</i>	1										1
<i>Polioptila caerulea</i>									1		1
<i>Polioptila melanura</i>		1		1	2	1	3		2	2	12
<i>Porzana carolina</i>	1										1
<i>Psa min</i>						5			2	1	8
<i>Regulus calendula</i>									1		1
<i>Salpinctes obsoletus</i>		10									10
<i>Sayornis nigricans</i>						1					1
<i>Sayornis saya</i>		2			2			2		6	12
<i>Selasphorus rufus</i>					1	1					2
<i>Setophaga petechia</i>						1			6		7
Set pol						1					1
Set sp									1		1
<i>Sialia currucoides</i>							1				1
<i>Spizella pallida</i>							1				1
<i>Sturnella neglecta</i>					1						1
<i>Tachycineta bicolor</i>				3					1		4
<i>Tachycineta bicolor</i>								1			1

Tac tha				1							1
<i>Thryomanes bewickii</i>					1						1
<i>Toxostoma curvirostre</i>		1	1	2	1		2	3	6	1	17
<i>Toxostoma lecontei</i>				3							3
<i>Tyrannus verticalis</i>	1								1	6	8
<i>Vireo gilvus</i>						1					1
<i>Wilsonia pusilla</i>						1			1		2
<i>Zenaida asiatica</i>	5								15		20
<i>Zenaida macroura</i>	1	6	2	14	7	1	9		5	2	47
<i>Zonotrichia leucophrys</i>		1				8		1	2	1	13
Grand Total	72	51	61	44	58	56	48	90	81	55	616

Appendix F: Social media post by OPCNM about observations of Ferruginous Pygmy-Owls linked to our project efforts that garnered 250 likes and 32 shares on Facebook.



Organ Pipe Cactus National Monument
May 28, 2021 · 🌐

...

We're owl so excited to share that there's been TWO confirmed reports of Cactus Ferruginous Pygmy-owls (CFPO) in the monument!

With the help of Tohono O'odham Nation and University of Arizona biologists, we confirmed what appears to be an unpaired male, and another individual we believe is female.

This subspecies was federally listed in 1997 as Endangered Distinct Population Segment for the Arizona population, but was later removed from the listing in 2006. USFWS is currently relooking at whether these owls need to be listed again.

Organ Pipe is near the northern boundary of this owl's range, and their populations seem to fluctuate widely with habitat and drought conditions. CFPO are the 2nd smallest owl in North America (Elf Owls come in at number one!). This species tends to be crepuscular, meaning active at dawn and dusk, and they feed primarily on lizards, birds, arthropods, and small mammals. This is Organ Pipe's 3rd year in a row of conducting surveys for CFPO after not surveying for the species since 2015.

NPS Photo/DMartin
Image: Cactus Ferruginous Pygmy-owl peers through the branches of a mesquite tree.





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