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Breeding by western Yellow-billed Cuckoos in xeroriparian habitat in southeastern Arizona

Reproducción del Cuclillo de pico amarillo occidental en hábitat xeroripario en el sudeste de Arizona

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ABSTRACT. The identification of occupied habitat is an important component of recovery efforts for threatened and endangered species. The western population of the Yellow-billed Cuckoo (*Coccyzus americanus*), federally listed as a threatened distinct population segment, has long been considered a riparian-obligate, yet recent survey efforts in southeastern Arizona have documented cuckoos occurring in xeroriparian habitat during the nesting season. We investigated the distribution and breeding status of cuckoos in southeastern Arizona xeroriparian habitat by comparing the results of standardized call-playback surveys to the results of nest searching efforts in the same sites from 2018 to 2020. We then used this information to interpret more extensive survey data from 2013 to 2020 and develop an updated breeding distribution map for southeastern Arizona. We confirmed breeding in 94% of sites categorized as occupied according to survey results. Combining our data with previous survey data, we estimated a minimum of 100 occupied sites in southeastern Arizona xeroriparian habitat, representing a substantial increase in the known breeding population in Arizona. Occupied sites were concentrated in southern and western "Sky Island" mountain and foothill drainages, from 600–1800 m, with xeroriparian vegetation in a matrix of Madrean-evergreen woodland, semi-desert grassland, or desert scrub. Breeding by cuckoos in southeastern Arizona xeroriparian habitat is important for cuckoo conservation, but this habitat also faces potential threats from grazing, climate change, and development.

RESUMEN. La identificación de hábitat ocupado es un componente importante para los esfuerzos de recuperación de especies amenazadas y en peligro. La población occidental del Cuclillo de pico amarillo (*Coccyzus americanus*), federalmente listada como un segmento poblacional distinto amenazado, siempre ha sido considerada como una especie riparia obligada, sin embargo, recientes esfuerzos de censos en el sudeste de Arizona han documentado a cuclillos ocurriendo en hábitat xeroripario durante la época de anidación. Investigamos la distribución y el estado de reproducción de los cuclillos en el hábitat xeroripario del sudeste de Arizona, mediante la comparación de resultados de censos estandarizados de llamados-playback con los resultados de esfuerzos de búsqueda de nidos en los mismos sitios desde el 2018 al 2020. Luego usamos esta información para interpretar datos de censos más extensivos del 2013 al 2020 y desarrollamos un mapa actualizado de distribución de reproducción para el sudeste de Arizona. Confirmamos reproducción en 94% de los sitios categorizados como ocupados de acuerdo a resultados de censos. Combinando nuestros datos con datos de censos anteriores, estimamos un mínimo de 100 sitios ocupados en el hábitat xeroripario del sudeste de Arizona, representando un incremento sustancial a la población reproductiva conocida en Arizona. Los sitios ocupados estuvieron concentrados en el sur y oeste de la montaña "Sky Island" y drenajes de pie de monte, desde 600-1800 m, con vegetación xeroriparia en una matriz de bosque Madreano siempreverde, pastizal semi-desértico, o arbustal de desierto. La reproducción de los cuclillos en el hábitat xeroripario del sudeste de Arizona es importante para la conservación de cuclillos, pero este hábitat también enfrenta amenazas potenciales de pastoreo, cambio climático y desarrollo.

Key Words: *biogeography; distribution; habitat; riparian; xeroriparian; Yellow-billed Cuckoo*

INTRODUCTION

Accurately assessing population distribution, numbers, and habitat associations is important for the management and recovery of threatened and endangered species (Joseph et al. 2006, Camaclang et al. 2015, Hughes 2015). Obtaining accurate and complete survey data may be especially challenging for rare or cryptic species, however, because of low or unknown detection probability (Gu and Swihart 2004, MacKenzie 2005, Martin et al. 2022), poor understanding of habitat preferences (Rosenfeld and Hatfield 2006), or temporal or spatial variation in occupancy (Wiens et al. 1987, Durso et al. 2011, Hayes and Monfils 2015). These factors all affect current understanding for the western distinct population segment (DPS) of the Yellow-billed Cuckoo (*Coccyzus americanus*; hereafter, "cuckoo"), a cryptic Neotropical migrant bird that was federally listed as threatened in 2014 (USFWS 2014).

Yellow-billed Cuckoos are widely distributed across sub-boreal North America (Hughes 2015). Although cuckoo numbers have decreased throughout their range, declines have been more significant across the western United States and extreme southwestern Canada (the "western DPS"; Gaines and Laymon 1984, Dettling et al. 2015, Hughes 2015), with most of the remaining population now in Arizona, New Mexico, southern California, and northern Sonora (Hughes 2015, USFWS 2021). Cuckoos are notably cryptic, exhibiting low call rates, large home

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ranges, a delayed breeding season, and rapid nesting cycle (Hamilton and Hamilton 1965, Halterman 2009, McNeil et al. 2013, Sechrist et al. 2013). They have also been hypothesized to have a nomadic period before nesting during which they may wander widely to assess prey availability (Sechrist et al. 2012, McNeil et al. 2015), making it difficult to determine whether detections in atypical vegetation types or early in the season are breeding or transient birds. These behaviors present challenges in assessing site occupancy, breeding status, population numbers, distributional patterns, and habitat preferences.

Cuckoos in the western DPS commonly breed in riparian areas in broad, low-mid elevation, low-gradient floodplains. Habitat is typically dominated by riparian trees including cottonwood (*Populus* spp.) and willow (*Salix* spp.), often with multi-story or early successional structure and adjacent trees such as mesquite (*Prosopis* spp.; Anderson and Laymon 1989, Ahlers et al. 2016, Johnson et al. 2017, McNeil et al. 2013, Wohner et al. 2021). This is referred to as "Rangewide Habitat" (hereafter "rangewide riparian habitat") by the recent critical habitat rule issued by the U.S. Fish and Wildlife Service (USFWS 2021). These habitat conditions are supported by perennial surface or ground water (Snyder 2000), and the recruitment of riparian trees and resulting vegetation structure depend on seasonal flood regimes (Stromberg 1993, 2001, Lytle et al. 2017). In the southwestern United States, cuckoo survey efforts, ecological studies, and habitat modeling, have focused primarily on these cottonwood- and willow-dominated rangewide riparian habitats (Halterman 2009, Johnson et al. 2010, McNeil et al. 2013, Dettling et al. 2015, Wohner et al. 2021). Recent cuckoo surveys in mountain and foothill drainages in southeastern Arizona (hereafter "SE AZ"; Corman and Magill 2000, USFWS 2014, MacFarland and Horst 2015, 2017; C. Corson 2018, *unpublished data*), however, have documented cuckoo occurrence in mid- to upper-watershed drainages that are generally dry, with only intermittent or ephemeral surface water. The dominant trees along these drainage courses are typically a mix of velvet mesquite (*Prosopis velutina*), Arizona ash (*Fraxinus velutina*), Arizona walnut (*Juglans major*), netleaf hackberry (*Celtis reticulata*), and various oak species (*Quercus* spp.), depending on the elevation and aridity of the area. Tree density ranges from scattered individuals to small clumps to continuous bands along the edges of the drainage course, but the bands are typically narrow (one to a few trees in width; MacFarland and Horst 2016; C. Corson 2018, *unpublished data*). Cottonwood or willow are sometimes present but only in low numbers (MacFarland and Horst 2015, USFWS 2021). Adjacent uplands may comprise Madrean-evergreen woodland, semi-desert grassland, or desert scrub (Brown 1994, MacFarland and Horst 2015), again depending on aridity of the region. These areas are referred to as "Southwestern Habitat" in the critical habitat designation rule (USFWS 2021) and throughout this paper we refer to them as "SE AZ xeroriparian habitat" or simply "xeroriparian." Although breeding behavior has been observed anecdotally at some of these sites (MacFarland and Horst 2015, 2017), the extent to which detections in these SE AZ xeroriparian habitats reflected breeding birds rather than transients or migrants was unknown.

Breeding status of cuckoos in rangewide riparian habitat has typically been evaluated based on results of a standardized survey protocol using repeat-visit, call-playback methods along a survey transect (Halterman et al. 2015). To avoid unnecessary stress to cuckoos, nest searching is not a component of these protocol surveys, and few nests are incidentally detected because of the birds' cryptic behavior and nest concealment. Instead, breeding status and site occupancy is inferred at the end of the survey season by reviewing the location and timing of cuckoo detections within the survey site. Although this approach has been shown to accurately reflect breeding status in rangewide riparian habitat (Halterman 2009, McNeil et al. 2013), its applicability has not been assessed in SE AZ xeroriparian habitat. Interpretation of cuckoo occurrence and breeding status in SE AZ xeroriparian habitats is further complicated by geolocator studies indicating cuckoos regularly use southeastern Arizona for migration (Sechrist et al. 2012, McNeil et al. 2015) and historical accounts of cuckoos in upland vegetation in California during migration (Shelton 1911). Therefore, the spatial extent of breeding in this understudied and potentially significant habitat in SE AZ cannot be reliably assessed because of limited surveys and lack of careful assessment of breeding status in SE AZ xeroriparian habitat.

To evaluate the breeding status and distribution of cuckoos in SE AZ xeroriparian habitat, we first tested whether site occupancy and breeding status as estimated using the standard USFWS-accepted survey protocol (Halterman et al. 2015) accurately reflected breeding status by conducting both protocol surveys and intensive nest searching at a subset of sites in the region. We also conducted opportunistic nest searching in additional sites being informally surveyed. We then reevaluated previously collected survey data and developed a map of known breeding distribution and occupancy in SE AZ xeroriparian habitat.

METHODS

Study area

Our study area included major mountain ranges and foothills between the San Pedro River and the Baboquivari Mountains, but additional historic data collected east of the San Pedro River were compiled and included for analyses of distribution (Fig. 1). The study area lies within the broader, international "Madrean Sky Island Archipelago" region (hereafter, Sky Islands), which consists of prominent mountain ranges separated by desert valleys that extend from the southern terminus of the Colorado Plateau in Arizona and New Mexico to the northern Sierra Madre in Sonora and Chihuahua, Mexico (Brown 1994).

Site selection

We sampled 83 sites within our study area between 2018 and 2020. Each site was located in a vegetated drainage, with a survey transect of 1.5–2.5 km in length following the drainage bottom. To maximize our ability to test whether current survey protocols accurately reflect breeding status, 61 of these sites were selected non-randomly by choosing sites where cuckoos had been previously detected. The remaining 22 sites were selected using a stratified random sampling approach, which was initiated in 2019. Our 2018 survey results, together with eBird (2021) detection data for SE AZ xeroriparian habitat, indicated that the major vegetation associations where cuckoos occurred in July and August (peak nesting period in Arizona; Hamilton and Hamilton 1965, Hughes 2015) were in Apacherian-Chihuahuan Mesquite Upland Scrub, Madrean Encinal, and North American Warm Desert Riparian Forest and Woodland (associations from

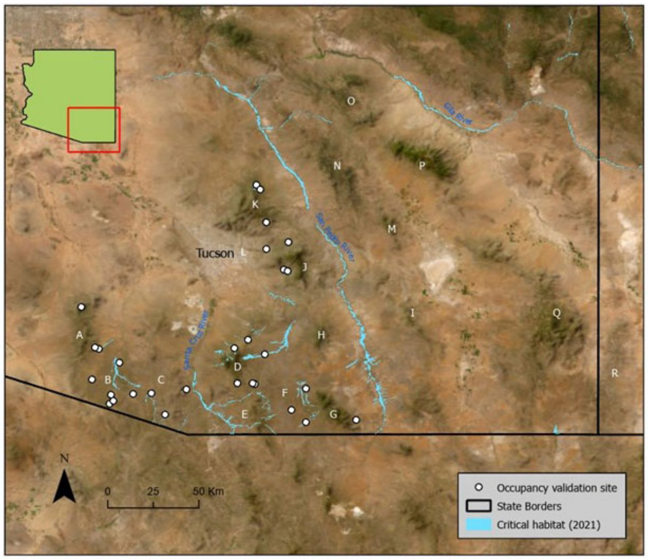


Fig. 1. Study area in southeastern Arizona, with locations of 37 sites used for assessment of Yellow-billed Cuckoo (*Coccyzus americanus*) occupancy and breeding, 2018–2020. Blue indicates designated critical habitat for the species (USFWS 2021). White letters denote localities mentioned in the text: (A) Baboquivari Mountains, (B) Altar Valley, (C) Atascosa Mountains, (D) Santa Rita Mountains, (E) Patagonia Mountains, (F) Canelo Hills, (G) Huachuca Mountains, (H) Whetstone Mountains, (I) Dragoon Mountains, (J) Rincon Mountains, (K) Santa Catalina Mountains, (L) Tucson Lowlands, (M) Winchester Mountains, (N) Galiuro Mountains, (O) Santa Teresa Mountains, (P) Pinaleño Mountains, (Q) Chiricahua Mountains, (R) Peloncillo Mountains.

LANDFIRE 2016). We then randomly selected grid cells having over 50% coverage of one or more of these LANDFIRE vegetation associations from a GIS coverage of the overall study area, with a 2 km x 2 km grid overlay. In each random grid cell, we selected a vegetated drainage bottom to survey. A total of 54 random sites were initially selected, and the first five or six drawn for each mountain range were used for survey sites, with the remaining selections serving as backups in the event we were unable to access the primary sites.

We selected 37 of the 83 sites to be used in our occupancy validation analysis, where we conducted protocol surveys in tandem with intensive nest searching between 2018 and 2020. Seven of these occupancy validation sites were from the randomly selected subset of sites while the rest were sites where cuckoos had been reported previously. In the remaining 46 sites (15 of which were from the randomly selected subset of sites), we either opportunistically documented breeding or conducted surveys without follow-up nest searching (see Mapping Distribution below), but these data were not used in the occupancy validation analysis.

Protocol surveys and nest searching

We surveyed for cuckoos using the currently established USFWS-accepted protocol (Halterman et al. 2015). Surveys consisted of call-playback at 100 m intervals along a pre-established transect that followed the main drainage at each site. To discourage detected cuckoos from following surveyors and inadvertently being double-counted, surveyors traveled a minimum of 300 m from detected birds before using playback again. All detection locations were recorded using handheld GPS, and the total number of individual cuckoos detected was estimated upon completion of each survey visit.

Following positive detections within a site, we conducted additional nest searching surveys to determine breeding status. Surveyors returned to the area of previous cuckoo detections with the goal of locating an active nest or observing other evidence of breeding including copulation, nest building, fledglings, or distraction displays. To avoid disturbance to potentially breeding birds, playback was used minimally, and we maintained a minimum distance of 10 m from birds while tracking individuals. Locations of nests or other breeding evidence were recorded using handheld GPS units. Breeding surveys were undertaken only after cuckoos were detected in a site during protocol surveys. If no cuckoos were detected in a site, no follow-up visits for breeding surveys were made.

The standard protocol (Halterman et al. 2015) calls for a minimum of four surveys per site, spaced 10–15 days apart, with the season lasting from 15 June to 15 August. We followed the protocol when conducting a survey on a single morning, referred to as a "survey visit." However, at some sites we deviated from the standard protocol by shifting the surveys two weeks later, and at some sites we ceased survey efforts after two or three survey visits if both positive occupancy status and positive breeding status had been established (see Occupancy Validation, below). We refer to any of these survey methods as "protocol surveys."

Occupancy validation

Upon completion of each survey season (2018–2020), data collected from sites were evaluated to estimate occupancy and breeding status according to an established protocol rubric (Halterman et al. 2015). "Occupancy" as used here refers to an evaluation of whether cuckoos were present at a site consistently during the breeding season; we did not perform a formal statistical occupancy analysis (cf. MacKenzie et al. 2002). We identified "occupied" territories as an area where cuckoos were detected during 2 or more survey periods, with survey visits separated by at least 10 days and with detection locations between surveys no greater than 500 m apart, and/or where evidence of breeding was observed incidentally during a survey visit or a follow-up to a survey visit. We therefore classified a site as "occupied" if one or more occupied territories were identified at that site. Sites were classified as "unoccupied," and therefore not assigned a breeding estimate, under three scenarios: (1) if no cuckoos were detected during any of at least four survey visits, (2) if cuckoos were detected during only one of at least four survey visits, or (3) if cuckoos were detected in two or more of at least four survey visits but no two detections from separate survey visits were < 500 m apart. We categorized scenarios 2 and 3 as "unoccupied with detection." These criteria allowed for sites to be included in occupancy validation if they were visited less than four times only if occupancy status had been established or breeding had been confirmed with fewer than four survey visits, as those results constituted a positive validation of the occupancy estimate without full effort. We did not include in our occupancy validation analysis either unoccupied sites with fewer than four survey visits or sites where cuckoos were detected but breeding was not confirmed because no additional follow-up nest searching was conducted.

The primary purpose of this study was to determine and document the occurrence and extent of nesting in these xeroriparian habitats, so we therefore assumed that occupancy of a site by a pair of cuckoos over the course of the nesting season was likely to be associated with attempted breeding. We further assumed that intensive nest-searching at a site where cuckoos were breeding would reliably confirm the breeding attempt. On this basis, each site was classified according to the standard survey protocol designation (Halterman et al. 2015) and its breeding status based on nest-searching efforts. This resulted in five possible classifications:

1. Occupied based on protocol surveys; breeding confirmed based on nest searching.
2. Occupied based on protocol surveys; breeding not confirmed based on nest searching.
3. Unoccupied based on protocol surveys; no breeding surveys due to unoccupied status.
4. Unoccupied with detection based on protocol surveys; breeding confirmed based on nest searching.
5. Unoccupied with detection based on protocol surveys; breeding not confirmed based on nest searching.

We then calculated the total number of each of these five classifications to determine overall proportion of sites in which occupancy status according to standard protocol survey designations accurately reflected attempted breeding, and proportions of sites where standard protocol survey designations of "occupied" or "unoccupied" did not agree with nest searching results (i.e., false positive or false negative). This evaluation, in turn, allowed us to evaluate whether site occupancy, as determined through protocol surveys, could reliably be used to assess extent and distribution of breeding by cuckoos in xeroriparian habitats. A total of 37 sites were included for our occupancy validation analysis, with three sites having two years of survey data, resulting in 40 survey records.

Mapping and evaluating distribution

Results from the occupancy validation were used to reevaluate occupancy estimation results from additional sites we surveyed between 2018 and 2020, as well as previous survey data collected between 2013 and 2020 (U.S. Fish and Wildlife Service, *unpublished data*) and contributed by other entities, including Tucson Audubon Society, Audubon Southwest, Saguaro National Park, Buenos Aires National Wildlife Refuge, Coronado National Forest, and the consulting firms Moors Biological Services, Archeological Consulting Services, and WestLand Resources Inc. Sites were classified according to their occupancy status based on standard protocol surveys. For sites with multiple years of data, the highest level of occupancy status was used to represent that site's "occupancy potential" in our map. In some sites, only three survey visits were conducted rather than the four required by the protocol. In these cases, we excluded sites that contained detections on only one of three survey visits and were classified as unoccupied because results from a fourth survey visit could possibly yield detections and elevate the site's status to occupied. However, we did retain sites classified as unoccupied with three negative survey visits, under the assumption that the fourth survey visit would not yield results sufficient for occupied status. Additionally, some surveyors shifted their survey window two weeks later to ensure their surveys extended into late August. We retained data for all of these sites given that this shifted schedule is intended to capture more of the breeding season in southeastern Arizona (Hamilton and Hamilton 1965). Sites with incidental detections not associated with protocol surveys were not included unless these detections confirmed breeding.

We mapped all sites that could be classified as occupied or unoccupied using the above criteria using ArcGIS (Environmental Systems Research Institute [ESRI] 2023. ArcGIS PRO. Release 3.2.2. Redlands, CA.), differentiating locations with confirmed breeding, occupied sites, and unoccupied sites. We also included polygons of designated critical habitat (USFWS 2021), representing known cuckoo habitat, which primarily consists of rangewide riparian habitat in perennial drainages and contains only a small subset of occupied xeroriparian habitat.

RESULTS

Occupancy validation

Twenty-four (60%) of 40 survey records resulted in an occupied status, with breeding evidence documented in 23 of them. Cuckoos were detected in 2 of 16 survey records classified as unoccupied, with no additional detections or breeding evidence documented in follow-up surveys. In the remaining 14 unoccupied survey records with no detections, unoccupied status was assumed to be valid, and no follow-up surveys or nest searching was conducted, so we therefore did not explicitly test for false negatives. Of the three sites with two years of survey data, one site was occupied in both years, one was unoccupied in both years, and one site was occupied in one year and unoccupied in the subsequent year.

Taken together, these results reflected only a single potential false-positive site (a site designated as occupied based on protocol surveys, but no evidence of breeding based on follow-up nest searching). Protocol surveys at this site (Brown Wash, Baboquivari Mountains) estimated three territories present based on detections in all six protocol surveys conducted between 26 June and 6 September, suggesting the lack of breeding confirmation at this site may have been failure of nest searchers to find the nests rather than absence of breeding. Regardless, these results demonstrated high confidence in the use of existing protocol survey criteria for estimating occupancy and breeding status.

Breeding surveys

In addition to confirmed breeding at the 23 sites used in the occupancy validation analysis, we opportunistically documented breeding at an additional 22 sites. Multiple breeding territories were documented at several of these sites, resulting in a total of 55 known breeding territories (Appendix 1). We documented 24, 26, and 5 breeding territories in 2018, 2019, and 2020, respectively (survey efforts were reduced in 2020). Evidence of breeding included 39 active nests, 11 observations of fledglings/juveniles, 3 observations of copulation, and 4 observations of distraction displays. Nests were placed in several tree species, including oak (*Quercus* spp.; 14), hackberry (*Celtis reticulata*; 12), mesquite

(*Prosopis* spp.; 4), juniper (*Juniperus* spp.; 3), acacia (*Senegalia greggii*; 2), ash (*Fraxinus velutina*; 2), yew-leaf willow (*Salix taxifolia*; 1), and cottonwood (*Populus fremontii*; 1). Nest monitoring was not a specific goal of our study, but we documented confirmed nesting success in 15 locations (based on observations of fledglings), nest failure in 2 locations, and were unable to determine nest fate in 38 locations where nests were not revisited. The earliest and latest dates of nesting activity were 3 July (active nest) and 11 September (nest with nestling), respectively. The earliest fledgling observation was 29 July, and the latest observation of copulation was 15 August.

Random sites

We surveyed 22 random sites across 7 mountain ranges in our study area. Of these, 68% (15) were occupied, including 6 of 7 random sites used for our occupancy validation. We were unable to survey sufficient random sites per mountain range to evaluate spatial trends in occupancy. However, our observed overall random site occupancy rate of 68% was consistent with our 61 non-random sites, where 70% of sites were occupied (Table 1). When we removed non-random sites from mountain ranges with no random sites, the occupancy rate of non-random sites was 73%. These results indicate targeted survey efforts tracked closely with results from randomly selected sites.

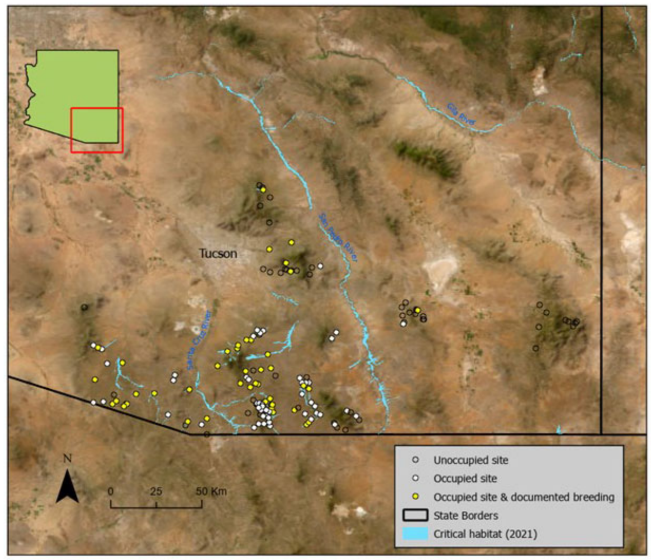
Table 1. Comparison of Yellow-billed Cuckoo (*Coccyzus americanus*) occupancy status results from random sites (n = 22) to non-random sites (n = 61), separated by survey area/mountain range in southeastern Arizona xeroriparian habitat, 2018–2020.

Area/Range	Random sites		Non-random sites		Total sites	
	Sites	Occupied (%)	Sites	Occupied (%)	Sites	Occupied (%)
Altar Valley	n/a	n/a	7	7 (100)	7	7 (100)
Atascosa Highlands	4	4 (100)	6	5 (80)	10	9 (90)
Baboquivari Mountains	n/a	n/a	3	2 (67)	3	2 (67)
Canelo Hills	5	3 (60)	9	7 (78)	14	10 (71)
Chiricahua Mountains	n/a	n/a	2	0 (0)	2	0 (0)
Dragoon Mountains	n/a	n/a	2	1 (50)	2	1 (50)
Huachuca Mountains	1	1 (100)	2	1 (50)	3	2 (67)
Patagonia Mountains	2	1 (50)	5	5 (100)	7	6 (86)
Rincon Mountains	5	3 (60)	8	2 (25)	13	5 (38)
Santa Catalina Mountains	1	0 (0)	3	1 (33)	4	1 (25)
Santa Rita Mountains	4	3 (75)	12	12 (100)	16	15 (94)
Whetstone Mountains	n/a	n/a	2	0 (0)	2	0 (0)
	22	15 (68)	61	43 (70)	83	58 (70)

Mapping distribution

We combined data we collected between 2018 and 2020 with available survey and nest searching data collected by other entities between 2013 and 2020 in SE AZ xeroriparian habitat, resulting in data for 163 sites in our southeastern Arizona study area (Fig. 2, Appendix 2). We documented breeding at 46 sites, either based on nest-searching or anecdotal evidence (serendipitous sighting of fledglings, copulation, etc.), and 54 sites were considered occupied based on surveys but were not revisited for nest-searching and had no anecdotal evidence of breeding, totaling 100 sites with confirmed breeding or occupancy. Eighteen sites were considered unoccupied sites with detections, and 45 were considered unoccupied sites with no detections (Fig. 2).

Fig. 2. Results of Yellow-billed Cuckoo (*Coccyzus americanus*) surveys and nest searching at 163 sites in southeastern Arizona between 2013 and 2020. Open circles are unoccupied sites, white circles are occupied sites (based on surveys), yellow circles are sites where breeding has been documented. Because of the scale of the map, sites within 1–2 km of each other have overlapping symbols.



As summarized in Table 1, occupied sites were numerous in the western portion of the Sky Islands, particularly in the region extending from the Baboquivari Mountains in the west, east through the Altar Valley, Atascosa Highlands, Santa Rita Mountains, Patagonia Mountains, Canelo Hills, San Rafael Valley, and finally the western side of the Huachuca Mountains. Some occupied sites were documented in the Whetstone Mountains, Rincon Mountains, and Santa Catalina Mountains, but we observed a higher proportion of unoccupied sites and surveyed fewer overall sites in these ranges. East of the San Pedro River, data contributed from other surveyors resulted in two occupied sites in the Dragoon Mountains and no occupied sites in the Chiricahua Mountains.

DISCUSSION

Previous studies of cuckoo habitat in the western United States stressed the importance of native riparian vegetation along major rivers and streams (Gaines 1974, Girvetz and Greco 2009, Johnson et al. 2017), while information on cuckoo breeding in SE AZ xeroriparian habitat has remained largely anecdotal. Our results expand the known range of breeding cuckoos and identify additional habitat for protection. We also demonstrated strong support for the use of the established survey protocol (Halterman et al. 2015) to determine breeding status in SE AZ xeroriparian habitat by verifying that breeding occurred in 97% (23 of 24) of sites designated as "occupied" using standard survey protocol estimates at our intensively monitored occupancy validation sites. Moreover, the percentage of randomly selected sites that were occupied was similar to that of non-random sites, suggesting our estimates of site occupancy were not biased by a priori site selection. This allowed us to extrapolate the results from the occupancy validation set of sites to other sites and to surveys carried out in other years, providing a larger temporal and spatial scale for assessing cuckoo presence across the Sky Islands region.

We documented 100 occupied sites between 2013 and 2020, including many sites with multiple nests or territories. Given that xeroriparian habitat was not adequately accounted for in previous studies, our results confirm the cumulative abundance of cuckoos using SE AZ xeroriparian habitat represents a significant addition to the known cuckoo population in Arizona. Direct comparisons to other cuckoo studies are difficult, however, because most previous studies occurred prior to the adoption of current survey protocols (Halterman et al. 2015), and used different survey and reporting methods. For example, Corman and Magill (2000) conducted statewide surveys in riparian habitat with detections in 84 of 145 sites, but estimating occupancy was not possible because they only surveyed each site once or twice per season. However, we documented cuckoos in a greater number of sites in the Sky Islands region than Corman and Magill (2000) documented statewide. Moreover, aside from relatively large populations in Arizona and New Mexico, cuckoos are uncommon elsewhere in the western DPS (USFWS 2021). In California, cuckoos have declined precipitously on the Sacramento River, with only 8 and 10 individual detections in 2012 and 2013, respectively, and no estimated territories (Dettling et al. 2015), while relatively small populations have fluctuated on the Kern River (Stanek 2013, 2017). Cuckoos are currently very uncommon in other western DPS states such as Colorado (Beason 2012), Utah (Howe and Hanberg 2000), and Idaho (Coates and Carlisle 2022). Given these notably small populations outside of Arizona and New Mexico, our results underscore the regional importance of SE AZ xeroriparian habitat.

Cuckoo habitat selection in riparian areas has been linked to canopy composition and cover, age class, and vegetation phenology (Gaines 1974, Wallace et al. 2013, Johnson et al. 2017, Stanek et al. 2021). Our results indicate cuckoos in SE AZ use a broader range of vegetative communities, with sites representing diverse physiographies from broad alluvial flats to narrow canyons, and a continuum of riparian conditions, with local vegetation ranging from isolated or narrow patches of riparian trees (cottonwood, willow, ash, walnut, etc.) to xeric ephemeral drainages with only oak, mesquite, and hackberry. The contrast in the xeroriparian vegetative communities occupied by cuckoos as documented here, compared to the cottonwood-willow riparian areas used by cuckoos, is also reflected in our list of nest tree species, with 78% (31 of 40) of nests found in oak, hackberry, or mesquite. In most cases, adjacent uplands contained either Madrean encinal woodland, semi-desert grassland (typically with interspersed shrubs and trees), or desert scrub (Brown 1994), all of which were used for foraging. These results expand the range of geophysical conditions and vegetation communities traditionally considered habitat for cuckoos. Drivers of occupancy in xeroriparian habitat, however, remain poorly understood and merit further investigation.

Geographically, our combined results indicate lower cuckoo occupancy in the northern and eastern portions of the Sky Islands region, with most occupied sites and breeding locations in the southern and western portions of the region. In particular, cuckoos were detected in most drainages surveyed in the Patagonia Mountains, Santa Rita Mountains, Canelo Hills, Atascosa Highlands, and Altar Valley. Many of these sites were located in the upper watersheds of rivers or creeks that support rangewide riparian habitat known to contain high numbers of cuckoos (e.g., San Pedro River, Santa Cruz River, Sonoita Creek). Whether and how often cuckoos move between these riparian and xeroriparian habitats, both within and between years, remains an important question. Importantly, our mapped distribution (Fig. 2) depicts known breeding locations and occupied survey sites and is not an estimate of actual distributional limits. Large geographic gaps in available data include the Baboquivari Mountains (west side), Galiuro Mountains, Winchester Mountains, Santa Teresa Mountains, Mule Mountains, Pinaleño Mountains, and Peloncillo Mountains, lower-elevation drainages in the Chiricahua Mountains, and in sub-ranges, foothills, and valleys between these major mountain ranges. Many of the gaps in survey coverage are either on private property or are remote and difficult to access. Although survey data from Mexico are limited (Macías-Duarte et al. 2015, 2023) and not included in our analyses, they are consistent with our findings in southeastern Arizona, suggesting use of xeroriparian vegetation in ephemeral drainages may extend into the Sierra Madre of Mexico. Therefore, additional survey efforts in under-surveyed areas of the Sky Islands region in both the United States and Mexico will help to further refine distribution and population estimates.

Our results support using existing protocols for estimating occupancy and breeding status based on survey results in xeroriparian habitat. However, we did not explicitly account for imperfect detection probability or test for false negative occupancy estimates, and it is therefore possible that sites classified as unoccupied were actually occupied. Furthermore, our data also suggests that multiple years of survey data may be necessary to reliably estimate occupancy at any given site. For example, in Upper Box Canyon in the Santa Rita Mountains, we discovered three nests in 2019, although no cuckoos were detected during any protocol surveys in 2020. Cuckoo occupancy in riparian habitat has also been shown to fluctuate between survey years (McNeil et al. 2019, Wohner et al. 2021). Therefore, given documented interannual variation in site occupancy and that individual detection probability with surveys is estimated to be 80% (Halterman et al. 2015), caution should be taken when designating sites as unoccupied, especially when only one year of data are available.

Our nesting data indicate cuckoos may often breed through August and as late as September in some sites (Appendix 2). This is consistent with Hamilton and Hamilton's (1965) findings of cuckoos in southern Arizona nesting later than cuckoos in southern California. Under current protocols, the fourth and final survey could hypothetically be completed on 1 August, potentially resulting in a nesting cycle occurring after surveys have ended. We suggest that for xeroriparian sites in southeastern Arizona, a more accurate breeding window may be captured with an additional late-season survey between 15 and 31 August or shifting the four required surveys approximately two weeks later (1 July–31 August).

Cuckoo populations are believed to have declined in rangewide riparian habitat primarily because of loss and degradation of bottomland riparian vegetation (USFWS 2014). Southwestern riparian ecosystems are projected to continue declining in response to climate change and increased anthropogenic change (Stromberg et al. 2013, Giermakowski et al. 2015, Eastoe 2020). Xeroriparian habitat, often occurring at higher elevation than rangewide habitat, may be less likely to be affected by some of these stressors such as dams and conversion to agriculture and therefore potentially serve as important refugia for cuckoos amid continued declines to bottomland riparian habitat. These xeroriparian drainages have also undergone varied and often significant anthropogenic changes, however, many of which present threats to habitat quality and resilience. For example, although livestock grazed some of our sites, and cuckoos have previously been documented utilizing actively grazed riparian areas (Hamilton and Hamilton 1965), livestock grazing may result in degradation to riparian and xeroriparian habitat (Stromberg 1993, Fleischner 1994, Brock and Green 2003, Goodrich et al. 2018). Alternative grazing practices and exclusion of cattle from riparian and xeroriparian drainages in southern Arizona have resulted in improvements to hydrological and ecological function (Krueper 2003, Beard 2004), and may benefit cuckoo habitat. Likewise, although cuckoos in our study area occupied sites that had experienced historical mining activity, modern industrial mining often occurs on a much larger scale with greater potential impacts to watershed hydrology, geochemistry, and habitat quality through direct habitat destruction, dewatering of aquifers, or otherwise redirecting or altering flows in drainages (Lewis and Burraychak 1979, Brock and Green 2003). Finally, climate change may act to increase aridification of southwestern uplands and exacerbate the risk of drought and fire, posing a threat to the resilience of SE AZ xeroriparian habitat (Bock and Bock 2014, Friggens et al. 2014). In spite of these potential threats, the number of breeding cuckoos we documented in these varied xeroriparian habitats, and the fact that many of those birds bred successfully, indicates these areas represent an important addition to known habitat for western Yellow-billed Cuckoo conservation and management.

Author Contributions:

N.D.B., T.C.T., S.J.S., and C.A.D. formulated questions; N.D.B., S.J.S., and C.A.D. collected data, and coordinated with partners and volunteers; N.D.B. and T.C.T. wrote the paper.

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Data Availability:

Data for this study are available at https://doi.org/10.5066/P19SDGDC.

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Appendix 1. List of 55 Yellow-billed Cuckoo (*Coccyzus americanus*) breeding locations documented in 45 sites in southeastern Arizona xeroriparian habitat, 2018–2020.

Site	**Drainage**	**Range/Locality**	**Year**	**Date Found**	**Evidence**	**Nest Outcome**	**Nest Tree**
Canoa Wash 1	Canoa Wash 1	Altar Valley	2018	8/4/2018	Nest	UNK	Hackberry
Canoa Wash 2	Canoa Wash 2	Altar Valley	2018	8/15/2018	Distraction display	UNK	n/a
Cuadro Wash	Cuadro Wash	Altar Valley	2018	8/8/2018	Juvenile	S	n/a
Las Guijas Wash 1	Las Guijas Wash 1	Altar Valley	2019	7/31/2019	Nest	UNK	Acacia
Las Guijas Wash 2	Las Guijas Wash 2	Altar Valley	2019	8/15/2019	Juvenile	S	n/a
Alamito Wash	Alamito Wash	Atascosa Highlands	2020	8/15/2020	Nest	UNK	Hackberry
Arivaca Lake (Random 108)	Arivaca Lake	Atascosa Highlands	2019	8/29/2019	Nest	S	Cottonwood
Arrieta Wash (Random 111)	Arrieta Wash	Atascosa Highlands	2019	8/14/2019	Nest	UNK	Mesquite
Dry Well 2 Dry Well (Random 104)	Fraguita Wash	Atascosa Highlands	2020	8/10/2020	Nest	UNK	Oak
Fresnal Wash North	Fresnal Wash	Atascosa Highlands	2018	8/17/2018	Nest	UNK	Hackberry
Fresnal Wash	Fresnal Wash	Atascosa Highlands	2020	8/22/2020	Nest	F	Hackberry
Rock Corral Canyon	Rock Corral Canyon	Atascosa Highlands	2018	8/11/2018	Juvenile	S	n/a
Sycamore Canyon	Sycamore Canyon	Atascosa Highlands	2018	9/1/2018	Nest	UNK	Yew-leaf Willow
Brown Canyon - Lower	Lower Brown Canyon	Baboquivari Mountains	2018	8/19/2018	Nest	S	Hackberry
Cherry Creek	Cherry Creek	Canelo Hills	2018	8/15/2019	Nest	UNK	Oak
Jones Canyon	Jones Canyon - Parker Canyon tributary	Canelo Hills	2019	8/12/2019	Nest	UNK	Oak
Lyle Canyon	Lyle Canyon	Canelo Hills	2018	8/2/2018	Distraction display	UNK	n/a
Lyle Canyon	Lyle Canyon	Canelo Hills	2019	9/3/2019	Juvenile	S	n/a
O'donnell Canyon	O'donnell Canyon	Canelo Hills	2019	8/6/2019	Fledgling	S	n/a
Parker Canyon / Parker Canyon 2 (Random 210)	Parker Canyon	Canelo Hills	2019	8/12/2019	Copulation	UNK	n/a
Casa Arroyo	Sonoita Creek - Unnamed Tributary	Canelo Hills	2020	7/30/2020	Nest	S	Oak
Halfmoon Ranch	Stronghold Canyon East	Dragoon Mountains	2019	7/31/2019	Fledgling	S	n/a
Goldbaum Canyon	Goldbaum Canyon	Patagonia Mountains	2018	9/2/2018	Fledgling	S	n/a
Harshaw Creek Nest 1	Harshaw Creek	Patagonia Mountains	2018	7/23/2018	Nest	UNK	Mesquite
Harshaw Creek Nest 1 2	Harshaw Creek	Patagonia Mountains	2019	8/5/2019	Nest	UNK	Oak

SE of Red Mtn/Lead Queen Nest 2 (Random 166)	Lead Queen (Unnamed Canyon) - Harshaw Creek Complex	Patagonia Mountains	2020	7/27/2020	Nest	UNK	Oak
SE of Red Mtn/Lead Queen Nest 1 (Random 166)	Lead Queen (Unnamed Canyon) - Harshaw Creek Complex	Patagonia Mountains	2019	8/5/2019	Nest	UNK	Juniper
Willow Springs Canyon	Willow Springs Canyon	Patagonia Mountains	2018	8/3/2018	Nest	UNK	Oak
Chiminea Canyon - Upper (Random 44)	Chiminea Canyon	Rincon Mountains	2019	7/30/2019	Fledgling	S	n/a
Rincon Creek - North	Rincon Creek	Rincon Mountains	2019	7/30/2019	Nest	UNK	Acacia
Italian Trap (Random 36)	Tanque Verde Creek	Rincon Mountains	2019	8/6/2019	Nest	UNK	Hackberry
Tanque Verde Wash - La Cebadilla	Tanque Verde Creek	Rincon Mountains	2018	8/16/2018	Nest	UNK	Mesquite
Peppersauce Canyon	Peppersauce Canyon	Santa Catalina Mountains	2018	8/23/2018	Nest	UNK	Oak
Adobe Canyon 1	Adobe Canyon	Santa Rita Mountains	2019	8/14/2019	Copulation	UNK	n/a
Adobe Canyon 2	Adobe Canyon	Santa Rita Mountains	2019	8/18/2019	Fledgling	S	n/a
Box Canyon 3 - Upper	Box Canyon	Santa Rita Mountains	2019	7/3/2019	Nest	UNK	Oak
Box Canyon 4 - Upper	Box Canyon	Santa Rita Mountains	2019	7/25/2019	Nest	UNK	Juniper
Box Canyon 5 - Upper	Box Canyon	Santa Rita Mountains	2019	7/24/2019	Nest	UNK	Oak
Box Canyon 1 - Lower	Box Canyon	Santa Rita Mountains	2018	7/29/2018	Nest	UNK	Hackberry
Box Canyon 2 - Lower	Box Canyon	Santa Rita Mountains	2018	7/26/2018	Nest	UNK	Juniper
Chino Canyon	Chino Canyon	Santa Rita Mountains	2018	7/29/2018	Nest	UNK	Mesquite
Florida Canyon 1	Florida Canyon	Santa Rita Mountains	2018	7/27/2018	Nest	UNK	Hackberry
Florida Canyon 2	Florida Canyon	Santa Rita Mountains	2018	8/23/2018	Nest	UNK	Hackberry
Gardner Canyon 1	Gardner Canyon	Santa Rita Mountains	2018	8/2/2018	Copulation	UNK	n/a
Gardner Canyon 2	Gardner Canyon	Santa Rita Mountains	2019	8/15/2019	Nest	S	Ash
Madera Canyon - Proctor Road	Madera Canyon	Santa Rita Mountains	2019	7/24/2019	Nest	UNK	Hackberry
Montosa Canyon 2	Montosa Canyon	Santa Rita Mountains	2020	8/16/2020	Nest	UNK	Hackberry
Smith Canyon	Smith Canyon	Santa Rita Mountains	2018	8/17/2018	Nest	UNK	Oak
Squaw Gulch (Random 124)	Squaw Gulch	Santa Rita Mountains	2019	8/7/2019	Nest	UNK	Oak
Stevens Canyon	Stevens Canyon	Santa Rita Mountains	2019	7/29/2019	Fledgling	S	n/a

Temporal Gulch 1 - Upper	Temporal Gulch	Santa Rita Mountains	2018	8/9/2018	Nest	UNK	Oak
Temporal Gulch 2 - Middle	Temporal Gulch	Santa Rita Mountains	2018	7/27/2018	Nest	UNK	Ash
Temporal Gulch 3 - Lower (Random 125)	Temporal Gulch	Santa Rita Mountains	2019	7/14/2019	Nest	UNK	Oak
W. Sawmill Canyon N 1 (Random 73)	W. Sawmill Canyon	Santa Rita Mountains	2019	7/20/2019	Juvenile	S	n/a
W. Sawmill Canyon S 2 (Random 73)	W. Sawmill Canyon	Santa Rita Mountains	2019	7/28/2019	Nest	F	Hackberry

S=successful, F=failed, UNK=unknown

Appendix 2. List of Yellow-billed Cuckoo (*Coccyzus americanus*) survey results collected from 163 sites in southeastern Arizona xeroriparian habitat, 2013–2020. In sites with multiple years of data, the highest recorded detection, occupancy, or breeding status is reported. In the last five columns, 0 = no, 1 = yes.

Site	Drainage	Range	Surveyor	Years Surveyed	Detection	Occupied	Breeding detected	Random Site	Occupancy Validation
Harshaw-Flux West	Alum Gulch	Patagonia Mountains	ACS	2018, 2019	1	0	0	0	0
Flux Canyon	Flux Canyon	Patagonia Mountains	ACS	2018	1	0	0	0	0
Flux Canyon Road	Flux Canyon and unnamed wash	Patagonia Mountains	ACS	2019	1	0	0	0	0
Harshaw Creek-FR4701	Harshaw Creek Complex	Patagonia Mountains	ACS	2018	0	0	0	0	0
Humboldt Canyon	Humboldt Canyon - Alum Gulch Complex	Patagonia Mountains	ACS	2018, 2019	0	0	0	0	0
Harshaw-FR 4701 East	unnamed wash near Humbolct C	Patagonia Mountains	ACS	2019	0	0	0	0	0
FR215 and Flux Canyon	Alum Gulch Complex	Patagonia Mountains	ACS	2019	1	1	0	0	0
Harshaw-Flux East	Alum Gulch Complex	Patagonia Mountains	ACS	2018, 2019	1	1	0	0	0
Harshaw Creek-FR4701 West	Harshaw Creek Complex	Patagonia Mountains	ACS	2019	1	1	0	0	0
La Osa Wash	La Osa Wash	Atascosa Highlands	AtoZ	2018	1	1	0	0	0
Telles Tank	Telles Tank	Canelo Hills	AWRR	2015, 2016, 2017, 2018	1	0	0	0	0
Lyle Canyon	Lyle Canyon	Canelo Hills	AWRR	2015, 2016, 2017, 2018, 2019, 2020	1	1	1	0	1
Lower Lyle Canyon (AWRR)	Lyle Canyon	Canelo Hills	AWRR	2016	1	1	0	0	0
Research Ranch HQ	O'Donnell Canyon	Canelo Hills	AWRR	2015, 2016, 2017,2018	1	1	0	0	0
Post Canyon	Post Canyon	Canelo Hills	AWRR	2016, 2017, 2018	1	1	0	0	0
Post Canyon (AWRR HQ)	Post Canyon	Canelo Hills	AWRR	2016	1	1	0	0	0
Vaughn Canyon	Vaughn Canyon	Canelo Hills	AWRR	2015, 2016, 2017, 2018	1	1	0	0	0
Fourr Canyon	Fourr Canyon	Dragoon Mountains	Moors	2017	0	0	0	0	0
Grapevine Canyon	Grapevine Canyon	Dragoon Mountains	Moors	2017	0	0	0	0	0
Jordan Canyon	Jordan Canyon	Dragoon Mountains	Moors	2017	0	0	0	0	0
Kerwin Canyon	Kerwin Canyon	Dragoon Mountains	Moors	2017	0	0	0	0	0
Noonan Canyon	Noonan Canyon	Dragoon Mountains	Moors	2017	0	0	0	0	0
Northfork Noonan Canyon	Noonan Canyon	Dragoon Mountains	Moors	2017	0	0	0	0	0

Upper Slavin Gulch	Slavin Gulch	Dragoon Mountains	Moors	2017	0	0	0	0	0
Stronghold East	Stronghold Canyon East	Dragoon Mountains	Moors	2017	0	0	0	0	0
Stronghold East Campground	Stronghold Canyon East	Dragoon Mountains	Moors	2017	0	0	0	0	0
Lower Stronghold West	Stronghold Canyon West	Dragoon Mountains	Moors	2017	0	0	0	0	0
Upper Stronghold West	Stronghold Canyon West	Dragoon Mountains	Moors	2017, 2020	0	0	0	0	0
Lower Slavin Gulch	Slavin Gulch	Dragoon Mountains	Moors	2017	1	1	0	0	0
Madrona Canyon	Madrona Canyon	Rincon Mountains	SAGU	2019, 2020	0	0	0	0	1
Box Canyon (Rincon)	Box Canyon	Rincon Mountains	SAGU	2019	0	0	0	0	0
Chiminea Canyon - Lower	Chiminea Canyon	Rincon Mountains	SAGU	2019	0	0	0	0	0
Ruiz Trail	Coyote Wash	Rincon Mountains	SAGU	2019, 2020	1	0	0	0	0
Rincon Creek - Sentinel Butte	Rincon Creek	Rincon Mountains	SAGU	2019, 2020	1	0	0	0	0
Rincon Creek Grotto	Rincon Creek	Rincon Mountains	SAGU	2020	1	0	0	0	0
Rincon Creek - North	Rincon Creek	Rincon Mountains	SAGU	2019, 2020	1	1	1	0	1
Ash Creek / Happy Valley (Random 52)	Ash Creek	Rincon Mountains	SAGU	2019	0	0	0	1	0
Rincon Creek (Random 47)	Rincon Creek	Rincon Mountains	SAGU	2019	0	0	0	1	0
Italian Trap (Random 36)	Tanque Verde Creek	Rincon Mountains	SAGU	2017, 2019	1	1	1	1	1
Chiminea Canyon - Upper (Random 44)	Chiminea Canyon	Rincon Mountains	SAGU	2019	1	1	1	1	0
Paige Creek (Random 48)	Paige Creek	Rincon Mountains	SAGU	2016, 2019	1	1	0	1	0
Las Guijas Wash	Las Guijas Wash	Altar Valley	SSP	2018, 2019	1	1	1	0	1
Brown Wash	Brown Wash	Altar Valley	SSP	2018	1	1	0	0	1
Vineyard Bosque	Arroyo Sasabe - Unnamed Tributary	Altar Valley	SSP	2018	1	1	0	0	0
Rock Corral Canyon	Rock Corral Canyon	Atascosa Highlands	SSP	2015, 2018	1	1	1	0	1
Sycamore Canyon	Sycamore Canyon	Atascosa Highlands	SSP	2015, 2018	1	1	1	0	1
Alamito Wash	Alamito Wash	Atascosa Highlands	SSP	2020	1	1	1	0	0
Fresnal Wash North	Fresnal Wash	Atascosa Highlands	SSP	2018, 2020	1	1	1	0	0
Arivaca Lake (Random 108)	Arivaca Lake	Atascosa Highlands	SSP	2015, 2019	1	1	1	1	1

Fresnal Wash South (Random 133)	Fresnal Wash	Atascosa Highlands	SSP	2018, 2019	1	1	1	1	0
Dry Well (Random 104)	Fraguita Wash	Atascosa Highlands	SSP	2020	1	1	1	1	1
Brown Canyon - Upper	Brown Canyon	Baboquivari Mountains	SSP	2018	1	1	0	0	0
Cherry Creek	Cherry Creek	Canelo Hills	SSP	2016, 2018	1	1	1	0	1
Jones Canyon	Jones Canyon - Parker Canyon tributary	Canelo Hills	SSP	2019	1	1	1	0	0
O'Donnell Canyon	O'Donnell Canyon	Canelo Hills	SSP	2019	1	1	1	0	0
Casa Arroyo	Sonoita Creek - Unnamed Tributary	Canelo Hills	SSP	2020	1	1	1	0	0
Lone Mountain Canyon (Random 214)	Lone Mountain Canyon	Canelo Hills	SSP	2019	0	0	0	1	0
Parker Canyon/ Park Canyon 2 (Random 210)	Parker Canyon	Canelo Hills	SSP	2019	1	1	1	1	1
O'Donnell Canyon Trib/N Pauline Cyn (Random 169)	O'Donnell Canyon - Unnamed Tributary	Canelo Hills	SSP	2019	1	1	0	1	0
Parker Canyon/ Park Canyon 1 (Random 208)	Parker Canyon	Canelo Hills	SSP	2020	1	1	0	1	0
Halfmoon Ranch, Stronghold Canyon	Stronghold Canyon	Dragoon Mountains	SSP	2019	1	1	1	0	0
Hunter Canyon	Hunter Canyon	Huachuca Mountains	SSP	2015, 2019	1	0	0	0	1
Ramsey Canyon (Random 204)	Ramsey Canyon	Huachuca Mountains	SSP	2015, 2020	1	1	0	1	0
Corral Canyon (FS 58)- San Rafael Valley Rd / Harshaw Creek	Corral Canyon - Harshaw Creek Complex	Patagonia Mountains	SSP	2013, 2018	1	1	1	0	0
Goldbaum Canyon	Goldbaum Canyon - Harshaw Creek Complex	Patagonia Mountains	SSP	2013, 2017, 2018, 2019	1	1	1	0	0

Harshaw Creek Nest 1	Harshaw Creek	Patagonia Mountains	SSP	2018	1	1	1	0	0
Harshaw Creek Nest 2	Harshaw Creek	Patagonia Mountains	SSP	2019	1	1	1	0	0
Cumero Canyon (Random 186)	Cumero Canyon	Patagonia Mountains	SSP	2020	0	0	0	1	0
Lead Queen Canyon (Random 166)	Lead Queen Canyon - Harshaw Creek Complex	Patagonia Mountains	SSP	2018, 2019, 2020	1	1	1	1	0
Tanque Verde Wash - La Cebadilla	Tanque Verde Creek	Rincon Mountains	SSP	2018	1	1	1	0	1
Bear Canyon (Random 21)	Bear Canyon	Santa Catalina Mountains	SSP	2019	0	0	0	1	1
Box Canyon - Upper	Box Canyon	Santa Rita Mountains	SSP	2015, 2017, 20192020	1	1	1	0	1
Florida Canyon	Florida Canyon	Santa Rita Mountains	SSP	2015, 2017, 2018	1	1	1	0	1
Gardner Canyon	Gardner Canyon	Santa Rita Mountains	SSP	2018, 2019	1	1	1	0	1
Smith Canyon	Smith Canyon	Santa Rita Mountains	SSP	2017, 2018, 2020	1	1	1	0	1
Stevens Canyon	Stevens Canyon	Santa Rita Mountains	SSP	2019	1	1	1	0	1
Adobe Canyon	Adobe Canyon	Santa Rita Mountains	SSP	2019, 2020	1	1	1	0	0
Box Canyon - Lower	Box Canyon	Santa Rita Mountains	SSP	2018	1	1	1	0	0
Madera Canyon (Proctor Road)	Madera Canyon	Santa Rita Mountains	SSP	2015, 2019, 2020	1	1	1	0	0
Montosa Canyon	Montosa Canyon	Santa Rita Mountains	SSP	2015, 2020	1	1	1	0	0
Temporal Gulch 1 - Upper	Temporal Gulch	Santa Rita Mountains	SSP	2018	1	1	1	0	0
Temporal Gulch 2 - Middle	Temporal Gulch	Santa Rita Mountains	SSP	2018	1	1	1	0	0
Big Casa Blanca Canyon (Random 99)	Casa Blanca Canyon - Unnamed Tributary	Santa Rita Mountains	SSP	2019	0	0	0	1	0
Squaw Gulch (Random 124)	Squaw Gulch	Santa Rita Mountains	SSP	2019	1	1	1	1	1
W Sawmill Canyon (Random 73)	Sawmill Canyon	Santa Rita Mountains	SSP	2019	1	1	1	1	0
Temporal Gulch 3 - Lower (Random 125)	Temporal Gulch	Santa Rita Mountains	SSP	2019	1	1	1	1	0
Canoa Wash 1 & 2	Canoa Wash	Altar Valley	SSP	2018	1	1	1	0	1
Cuadro Wash	Cuadro Wash	Altar Valley	SSP	2018	1	1	1	0	1

Santa Margarita Wash - Lower	Santa Margarita wash	Altar Valley	SSP	2018	1	1	0	0	0
Carpenter Tank	Lopez Wash	Atascosa Highlands	SSP	2018	0	0	0	0	1
Arrieta Wash (Random 111)	Arrieta Wash	Atascosa Highlands	SSP	2019	1	1	1	1	1
Kitt Peak	N/A	Baboquivari Mountains	SSP	2018	0	0	0	0	1
Brown Canyon - Lower	Brown Canyon	Baboquivari Mountains	SSP	2018	1	1	1	0	1
N Tributary /N of Cherry Creek (Random 191)	Cherry Creek - Unnamed tributary	Canelo Hills	SSP	2019	0	0	0	1	0
Willow Springs Canyon	Willow Springs Canyon - Harshaw Creek Complex	Patagonia Mountains	SSP	2013, 2018, 2019	1	1	1	0	0
Mariposa Canyon	Mariposa Canyon	Atascosa Highlands	TAS	2017	1	0	0	0	0
Pena Blanca Canyon	Pena Blanca Canyon	Atascosa Highlands	TAS	2015	1	0	0	0	0
Bellatosa Canyon	Bellatosa Canyon	Atascosa Highlands	TAS	2017	1	1	1	0	0
Pena Blanca Lake	Pena Blanca Canyon	Atascosa Highlands	TAS	2015	1	1	1	0	0
Pesquiera Canyon	Pesquiera Canyon	Atascosa Highlands	TAS	2017	1	1	0	0	0
Sardinia Canyon - 1	Sardinia Canyon	Atascosa Highlands	TAS	2017	1	1	0	0	0
Sardinia Canyon - 2	Sardinia Canyon	Atascosa Highlands	TAS	2017	1	1	0	0	0
Sycamore Canyon (Patagonia)	Sycamore Canyon	Atascosa Highlands	TAS	2015	1	1	0	0	0
Alamo Canyon	Alamo Canyon	Canelo Hills	TAS	2016	0	0	0	0	0
Collins Canyon	Collins Canyon	Canelo Hills	TAS	2015	1	1	0	0	0
Dove Canyon	Dove Canyon	Canelo Hills	TAS	2016	1	1	0	0	0
Korn Canyon	Korn Canyon	Canelo Hills	TAS	2015	1	1	0	0	0
Upper Lyle Canyon	Lyle Canyon	Canelo Hills	TAS	2015	1	1	0	0	0
Merritt Canyon	Merritt Canyon	Canelo Hills	TAS	2015	1	1	0	0	0
Cave Creek Canyon - SWRS	Cave Creek Canyon	Chiricahua Mountains	TAS	2015	0	0	0	0	0
Cave Creek Canyon (1) - Stewart Campground	Cave Creek Canyon	Chiricahua Mountains	TAS	2015	0	0	0	0	0
Cave Creek Canyon (1) - Stewart Campground	Cave Creek Canyon	Chiricahua Mountains	TAS	2017	0	0	0	0	0

Cave Creek Canyon (3) - Upper Canyon	Cave Creek Canyon	Chiricahua Mountains	TAS	2017	0	0	0	0	0
South Fork Cave Creek Canyon (2)	Cave Creek Canyon	Chiricahua Mountains	TAS	2015, 2017	0	0	0	0	0
Pine Canyon	Pine Canyon	Chiricahua Mountains	TAS	2017	0	0	0	0	0
Pinery Canyon	Pinery Canyon	Chiricahua Mountains	TAS	2017	1	0	0	0	0
East Turkey Creek	Turkey Creek	Chiricahua Mountains	TAS	2017	0	0	0	0	0
West Turkey Creek	West Turkey Creek	Chiricahua Mountains	TAS	2017	0	0	0	0	0
Carr Canyon	Carr Canyon	Huachuca Mountains	TAS	2015	0	0	0	0	0
Copper Canyon	Copper Canyon	Huachuca Mountains	TAS	2016	1	0	0	0	0
Ida Canyon	Ida Canyon	Huachuca Mountains	TAS	2016	0	0	0	0	0
Bear Canyon	Bear Canyon	Huachuca Mountains	TAS	2016	1	1	0	0	0
Miller Canyon	Miller Canyon	Huachuca Mountains	TAS	2015, 2018	1	1	0	0	0
Washington Gulch	Washington Gulch	Patagonia Mountains	TAS	2015	1	1	0	0	0
Turkey Creek	Turkey Creek	Rincon Mountains	TAS	2016	0	0	0	0	0
Campo Bonito	Bonito Canyon	Santa Catalina Mountains	TAS	2017, 2018, 2019	1	0	0	0	1
Alder Canyon	Alder Canyon	Santa Catalina Mountains	TAS	2017	0	0	0	0	0
Southern Belle Mine	Bonito Canyon	Santa Catalina Mountains	TAS	2018, 2019	1	0	0	0	0
Sabino Canyon	Sabino Canyon	Santa Catalina Mountains	TAS	2015	0	0	0	0	0
Stratton Canyon	Stratton Canyon	Santa Catalina Mountains	TAS	2017	0	0	0	0	0
Peppersauce Canyon	Peppersauce Canyon	Santa Catalina Mountains	TAS	2015, 2016, 2017, 2018, 2019	1	1	1	0	1
Mansfield Canyon	Mansfield Canyon	Santa Rita Mountains	TAS	2017	1	1	0	0	0
French Joe Canyon	French Joe Canyon	Whetstone Mountains	TAS	2015, 2016, 2018, 2019	1	1	0	0	0
Guindani Canyon	Guindani Canyon	Whetstone Mountains	TAS	2015, 2016, 2018, 2019	1	1	0	0	0
East South Fork Cave Creek Canyon	Cave Creek Canyon	Chiricahua Mountains	USFS	2020	1	0	0	0	0
West South Fork Cave Creek Canyon	Cave Creek Canyon	Chiricahua Mountains	USFS	2020	1	0	0	0	0
Temporal Gulch 2 - Middle / Mansfield East	Temporal Gulch	Santa Rita Mountains	USFS	2020	1	1	0	0	0
Corral Canyon (5) - N Tributary	Corral Canyon	Patagonia Mountains	WestLand	2013	1	0	0	0	0

Corral Canyon (6) - NW Tributary	Corral Canyon	Patagonia Mountains	WestLand	2013	0	0	0	0	0
Endless Chain Canyon	Endless Chain Canyon	Patagonia Mountains	WestLand	2015	0	0	0	0	0
Upper Harshaw Creek	Harshaw Creek	Patagonia Mountains	WestLand	2017	0	0	0	0	0
Hermosa Hill	Harshaw Creek - Unnamed Tributary	Patagonia Mountains	WestLand	2016, 2017, 2018, 2019, 2020	1	0	0	0	0
Lower Alum Gulch	Alum Gulch	Patagonia Mountains	WestLand	2017, 2018, 2019	1	1	0	0	0
Corral Canyon	Corral Canyon	Patagonia Mountains	WestLand	2013, 2018, 2019	1	1	0	0	0
Lower Finley & Adams Canyon	Finley & Adams Canyon	Patagonia Mountains	WestLand	2015, 2017, 2018, 2019	1	1	0	0	0
Upper Finley & Adams Canyon	Finley & Adams Canyon	Patagonia Mountains	WestLand	2017, 2018, 2019	1	1	0	0	0
Harshaw C-FS 4701 to Guajolote Flat	Harshaw Creek	Patagonia Mountains	WestLand	2017, 2018, 2019, 2020	1	1	0	0	0
Harshaw Creek (1, 2)	Harshaw Creek	Patagonia Mountains	WestLand	2013, 2016, 2017, 2018, 2019, 2020	1	1	0	0	0
Basin Mine	Harshaw Creek - Unnamed Tributary	Patagonia Mountains	WestLand	2018, 2019, 2020	1	1	0	0	0
Great Silver Mine	Harshaw Creek - Unnamed Tributary	Patagonia Mountains	WestLand	2018, 2019, 2020	1	1	0	0	0
Unnamed Canyon E of Hermosa	Harshaw Creek - Unnamed Tributary	Patagonia Mountains	WestLand	2017, 2018, 2019	1	1	0	0	0
Hermosa Canyon	Hermosa Canyon	Patagonia Mountains	WestLand	2013, 2017, 2018, 2019, 2020	1	1	0	0	0
Humboldt and Upper Alum	Humboldt Canyon	Patagonia Mountains	WestLand	2016, 2017, 2018, 2019, 2020	1	1	0	0	0
East Mowry Wash	Mowry Wash	Patagonia Mountains	WestLand	2019	1	1	0	0	0
West Mowry Wash	Mowry Wash	Patagonia Mountains	WestLand	2018, 2019	1	1	0	0	0
Paymaster Canyon - Flying R Ranch	Paymaster Canyon	Patagonia Mountains	WestLand	2015, 2016, 2018, 2019	1	1	0	0	0
Lower Sycamore Canyon	Sycamore Canyon	Patagonia Mountains	WestLand	2017, 2018, 2019	1	1	0	0	0
Upper Sycamore Canyon	Sycamore Canyon	Patagonia Mountains	WestLand	2017, 2018, 2019	1	1	0	0	0
Rosemont Springs	Barrel Canyon	Santa Rita Mountains	WestLand	2013, 2014, 2018	0	0	0	0	0
Lower Barrel Canyon	Barrel Canyon	Santa Rita Mountains	WestLand	2013, 2014, 2015, 2017, 2018	1	1	0	0	0

Upper Barrel Canyon	Barrel Canyon	Santa Rita Mountains	WestLand	2013, 2014, 2015, 2017, 2018	1	1	0	0	0
McCleary Canyon	McCleary Canyon	Santa Rita Mountains	WestLand	2013, 2014, 2016, 2017, 2018	1	1	0	0	0
Wasp Canyon	Wasp Canyon	Santa Rita Mountains	WestLand	2013, 2014, 2015, 2016, 2017, 2018	1	1	0	0	0