Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation

Amphibian Monitoring on the Bill Williams River

2014 Annual Report

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

April 2016

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Lower Colorado River Multi-Species Conservation Program

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2014 Annual Report

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ACRONYMS AND ABBREVIATIONS

BWR	Bill Williams River
CRTO	Colorado River toad(s) (*Incilius alvarius*)
DAR	digital automated recorder(s)
eDNA	environmental deoxyribonucleic acid
GPS	Global Positioning System
LCR	lower Colorado River
LCR MSCP	Lower Colorado River Multi-Species Conservation Program
m	meter(s)
PIT	passive integrated transponder
Reclamation	Bureau of Reclamation
VES	visual encounter survey(s)

Symbols

#	number

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ABSTRACT

The Arizona Game and Fish Department embarked on this study to determine the most cost-effective and efficient methods for long-term monitoring of amphibians along the lower Colorado River (LCR). Four different methods were tested to determine the presence of Colorado River toads (*Incilius alvarius*) (CRTO) around the Bill Williams River, La Paz and Yuma Counties, Arizona. These methods included visual encounter surveys (VESs) with an audio call-playback component, funnel trap arrays, environmental deoxyribonucleic acid (eDNA) testing, and the use of digital automated recorders (DARs). Surveys using these methods were conducted during the breeding and activity season, which occurs during summer monsoons. The surveys ran from July 8 through October 4, 2014. CRTO were detected 11 times during VES surveys, 7 times during audio call-playback surveys, 0 times during funnel trap surveys, and 84 times using DARs. The results from eDNA are still pending. Thus far, it would appear that the VES and DAR methods are producing the most affirmative means for monitoring CRTO populations.

INTRODUCTION

Colorado River toads (*Incilius alvarius*) (CRTO) are believed to be extirpated from the main stem of the Colorado River (Brennan and Holycross 2006). However, a small population exists on the Bill Williams River (BWR) (Cotten 2011), a tributary to the lower Colorado River (LCR). CRTO are an evaluation species under the Lower Colorado River Multi-Species Conservation Program (LCR MSCP) and are in need of conservation measures in this portion of their range along the LCR (Bureau of Reclamation [Reclamation] 2004). The activity and breeding behavior of CRTO is dependent on summer monsoon rains, with breeding occurring after a large rain of more than 25 millimeters (Sullivan and Malmos 1994; Sullivan and Fernandez 1999). The unpredictability of these rains makes surveying for this species difficult, so the goal was to develop a repeatable monitoring strategy for CRTO within the LCR that is both cost effective and efficient. To do this, the Arizona Game and Fish Department wanted to test and evaluate several different methods to effectively survey for CRTO within an extant population on the BWR. Four methods were tested, which included visual encounter surveys (VESs) with an audio call-playback component, funnel trap arrays, environmental deoxyribonucleic acid (eDNA) testing, and the use of digital automated recorders (DARs).

OBJECTIVE

The objective of this project was to develop and implement a repeatable monitoring strategy that can be used on the LCR to survey for CRTO in the future.

STUDY AREA

The study area is located on the Bill Williams River near Arizona's western border (figure 1). The study site is located approximately 24 kilometers east of the confluence with the LCR. It begins at the eastern border of Planet Ranch (private property) and proceeds east approximately 7 kilometers along the BWR and into Bureau of Land Management managed public land and the Swansea Wilderness Area (figure1).

METHODS

Ten study plots, each 500 x 1,000 meters (m) (5 hectares), were set up along the BWR on Bureau of Land Management managed public land east of Planet Ranch where a known population of CRTO exists (Cotten and Grandmaison 2012). From the eastern border of Planet Ranch, plots were placed east or upstream consecutively along the river (figure 1).

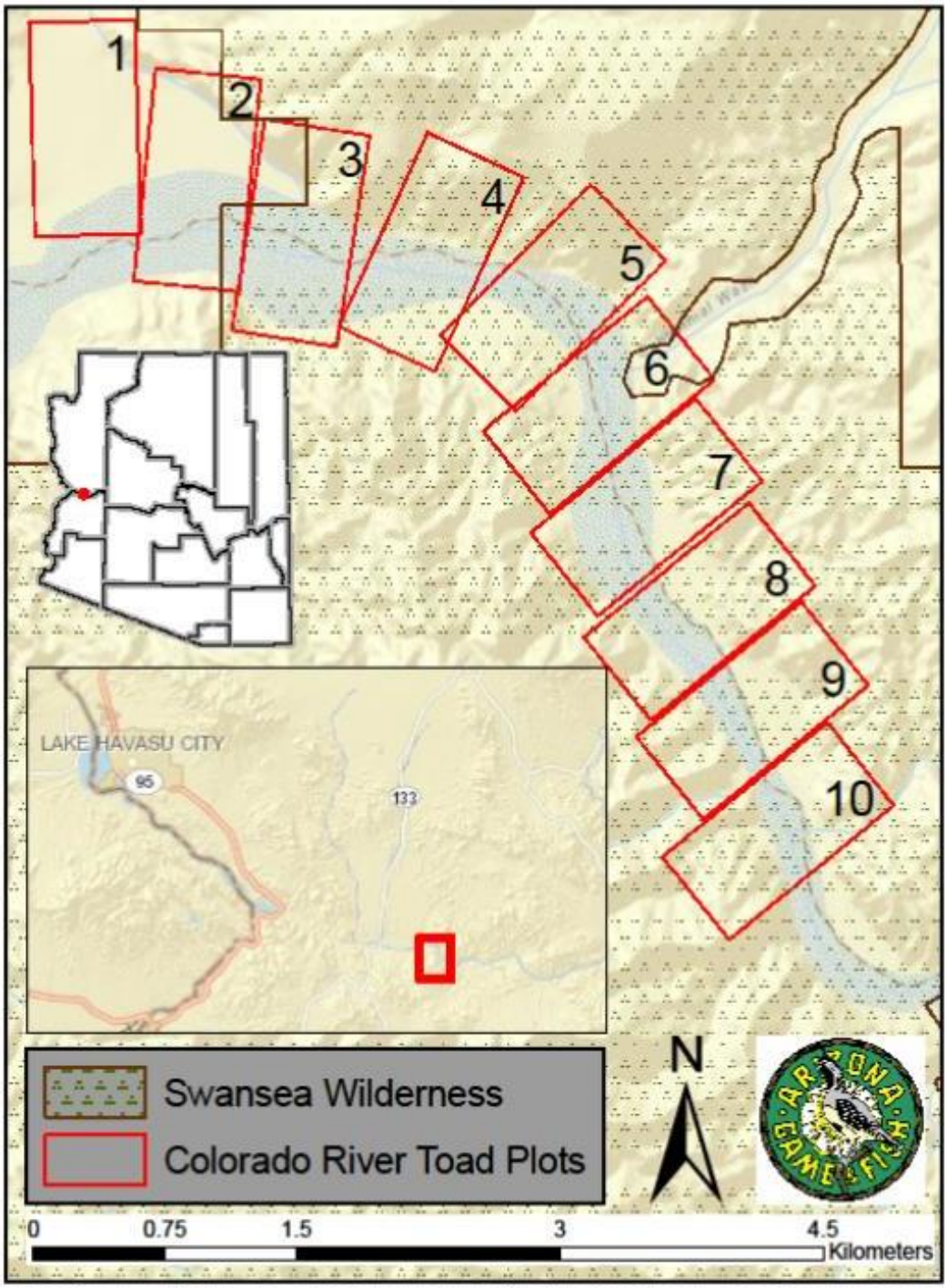

Figure 1.—Map of survey site and CRTO plots on the BWR.

Surveys were conducted during the summer monsoon season, which begins in July and continues through mid-September (Adams and Comrie 1997; Adang and Gall 1989). Surveys began on July 8, 2014, and continued until October 4, 2014, which encompassed the monsoon and CRTO breeding season. Typically, CRTO breed in monsoonal ephemeral pools (Brennan and Holycross 2006). All data were collected digitally with Trimble® Nomad Global Positioning System units and Terrasync® software. Mobile electronic field forms were created for each survey method to assure data were recorded in the exact same manner for each method by all surveyors. Data were also recorded on paper data sheets to back up the digital data and to aid with quality assurance and quality control. Once data were run through quality assurance and quality control, the information was exported into a Microsoft Access® database through the program GPS Pathfinder®.

Visual Encounter and Call-Playback Surveys

A minimum of four surveys were performed at each plot, with no plot receiving more than seven. Surveys were set on a predetermined schedule starting with plots 1 and 2 for 2 nights, then 3 and 4 for 2 nights, and so on until plots 9 and 10 were completed. This process was repeated four times. The goal was to survey six plots per visit. Once that number was attained, the surveys continued in chronological order as the schedule allowed. Each VES consisted of a 2-hour survey period starting 1 hour prior to sunset and continuing throughout the night. One to three surveys were completed on a nightly basis. Surveys consisted of Arizona Game and Fish Department biologists walking a plot with flashlights to detect adult CRTO, egg masses, or tadpoles. Gender, location, and life stage for each individual captured were recorded. Captured individuals were then marked with a passive integrated transponder (PIT) tag. Information on any other species of amphibian or reptile seen on a plot during a survey was also recorded. Included in a VES was an audio call-playback survey. Each audio survey used a FOXPRO Inc. © broadcast caller to play a CRTO advertisement call. The call was played for two cycles, each approximately 30 seconds long, followed by a break to listen for a response. This was repeated a minimum of four times by systematically calling every 30 minutes throughout each VES. Calling by any amphibian species during a call survey was recorded. Finally, any suitable breeding sites detected were noted for other survey methods.

Funnel Traps

If water was found during a VES, inverted conical wire mesh funnel traps (Gee minnow traps) were used to capture individuals (Heyer et al. 1994). Four clusters of 10 traps were set for 2 nights and checked twice during that time period. They were typically set along banks in order to encourage natural flow through the trap

and to mimic a drift fence. No bait was placed in the traps. They were set in water only to the height of the funnel, leaving space at the top so any amphibian or reptile species caught had access to air. All non-target species were noted and released.

Environmental Deoxyribonucleic Acid (eDNA)

This method can reliably determine presence of a species by identifying trace amounts of genetic material of the target species suspended in the water column and is especially useful at detecting species that are either hard to find, difficult to survey, or have a low density (Ficetola et al. 2008). Water samples were collected at any site where a funnel trap cluster was set. Typically they were collected after the first trap night. Between 1,000 and 2,000 milliliters of water was collected from each site, and each sample was forced through a 0.45-micron filter. A negative or blank sample, one in which no genetic material exists, was also processed before stream samples were collected using distilled water to reduce any potential for false positives. Filters were placed in a vial of 95% ethanol solution, labeled, and stored for later analysis. Samples have been sent to Reclamation, Environmental Applications and Research Group, in Denver, Colorado (results pending). Some samples were also sent to Washington State University for analysis (pending).

Digital Automated Recorders

The benefits of using DARs are a lengthened sampling time by passively recording data while biologists are not present onsite, the ability to lessen disturbance to the target species during calling, and the ability to retain a saved recording for further analysis, which are all valuable components for detecting anurans (Bridges and Dorcas 2000). A Wildlife Acoustics Song Meter SM2+ automated recording device was set in each study unit for a total of 87 nights (figure 2). They were set along the river channel as close to the center of each plot as possible. Each recorder was set to record 1 minute of every hour on the hour from 2100 through 0200 each night from the first day to the final day of the study season. Recordings were downloaded in the field and evaluated in either the field lab or a headquarters lab setting. Any amphibian calls heard during the recordings were noted along with the time and number of individuals thought to be calling.

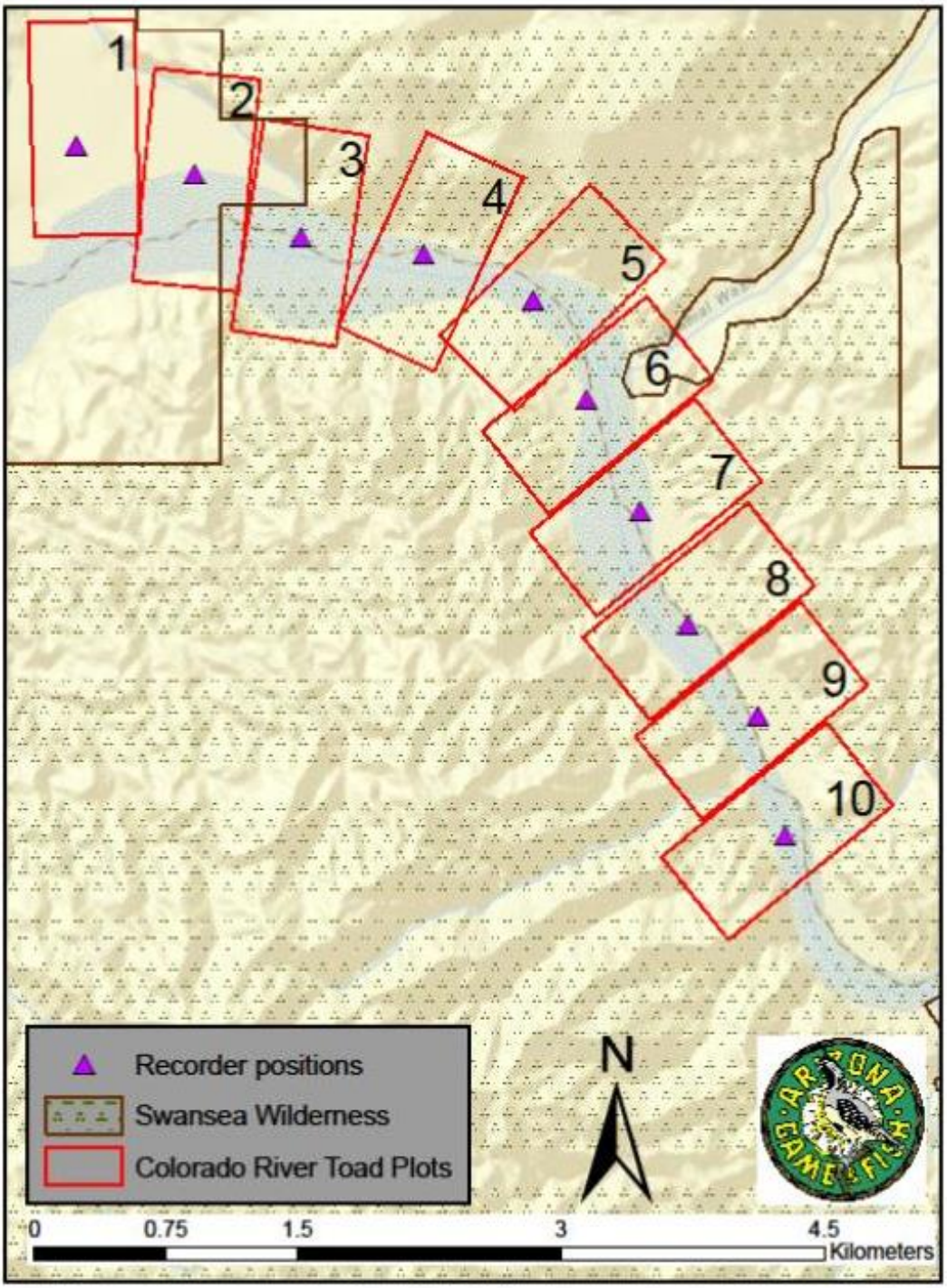

Figure 2.—DAR locations on the BWR.
Purple triangles represent locations of each DAR.

RESULTS

Visual Encounter and Call-Playback Surveys

A total of 54 VESs were conducted throughout the season. Eleven CRTO were captured, with one male (PIT #: 982000363544294) recaptured once. Captures occurred on plots 1, 2, 5, and 6 (figure 3). Plot 6 had seven captures, four of which were on the same night at a recently created ephemeral pool. Plot 2 had two captures, and plots 1 and 5 each had a single capture. Callbacks were heard during a total of seven VESs. Calling was heard from plots 4, 5, 6, 7, and 8 (figure 3). All call responses came from outside the surveyed plot except for one on plot 5. Two amplectic pairs were observed on plot 5 on August 5, 2014, as well as two egg masses on August 7, 2014. Plot 6 had calling males, but no females or egg masses were observed.

Funnel Traps

Funnel traps were deployed for 6,100 trap-hours on plots 5, 6, and 10 due to water availability (figure 4). Three sessions of trapping occurred on plots 5 and 6, totaling 5 nights for each plot. Dates for trapping events occurred on both plots on the nights of August 7 and 8, 2014, September 3, 2014, and September 23 and 24, 2014. Plot 5 had seven trap clusters set throughout the season, and plot 6 had eight. Plot 10 only had 1 night of trapping as water levels in the plot receded between the first and second day of the only available trapping event on October 2, 2014. Limited water in plot 10 only allowed for 2 clusters to be set. No target species were captured through trapping. Non-target herpetofauna species captured during trapping sessions included Couch's spadefoot (*Scaphiopus couchii*), red-spotted toad (*Anaxyrus punctatus*), and northern Mexican gartersnake (*Thamnophis eques*) as well as crayfish (*Orconectes virilis*) and various macroinvertebrates.

Environmental Deoxyribonucleic Acid (eDNA)

A total of 11 eDNA samples were collected where ample water was available (figure 5). Four samples were collected from plot 5, 5 from plot 6, and 2 from plot 10. One sample was collected from each trap array that was set at each plot. Samples were collected on August 8, 2014, and September 3, 2014, on plots 5 and 6. Samples for plot 10 were collected on October 3, 2014. Samples were not collected for trap arrays set on plots 5 and 6 during the September 23–25, 2014, deployment. Samples have been sent to Reclamation, Environmental Applications and Research Group, in Denver, Colorado (results pending).

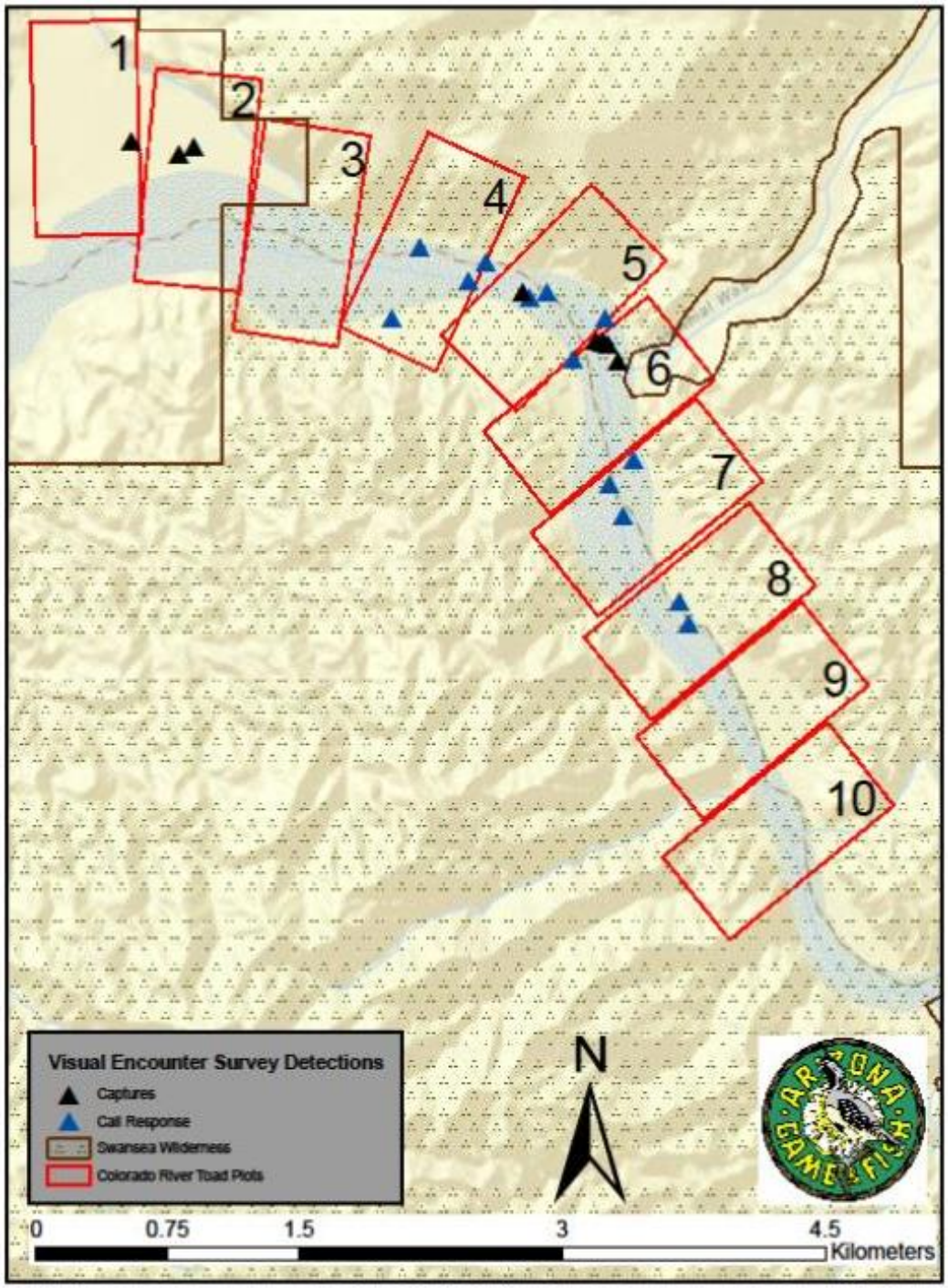

Figure 1.—VESs and call response detection locations on the BWR.
Black triangles represent VESs. Blue triangles represent call response locations.

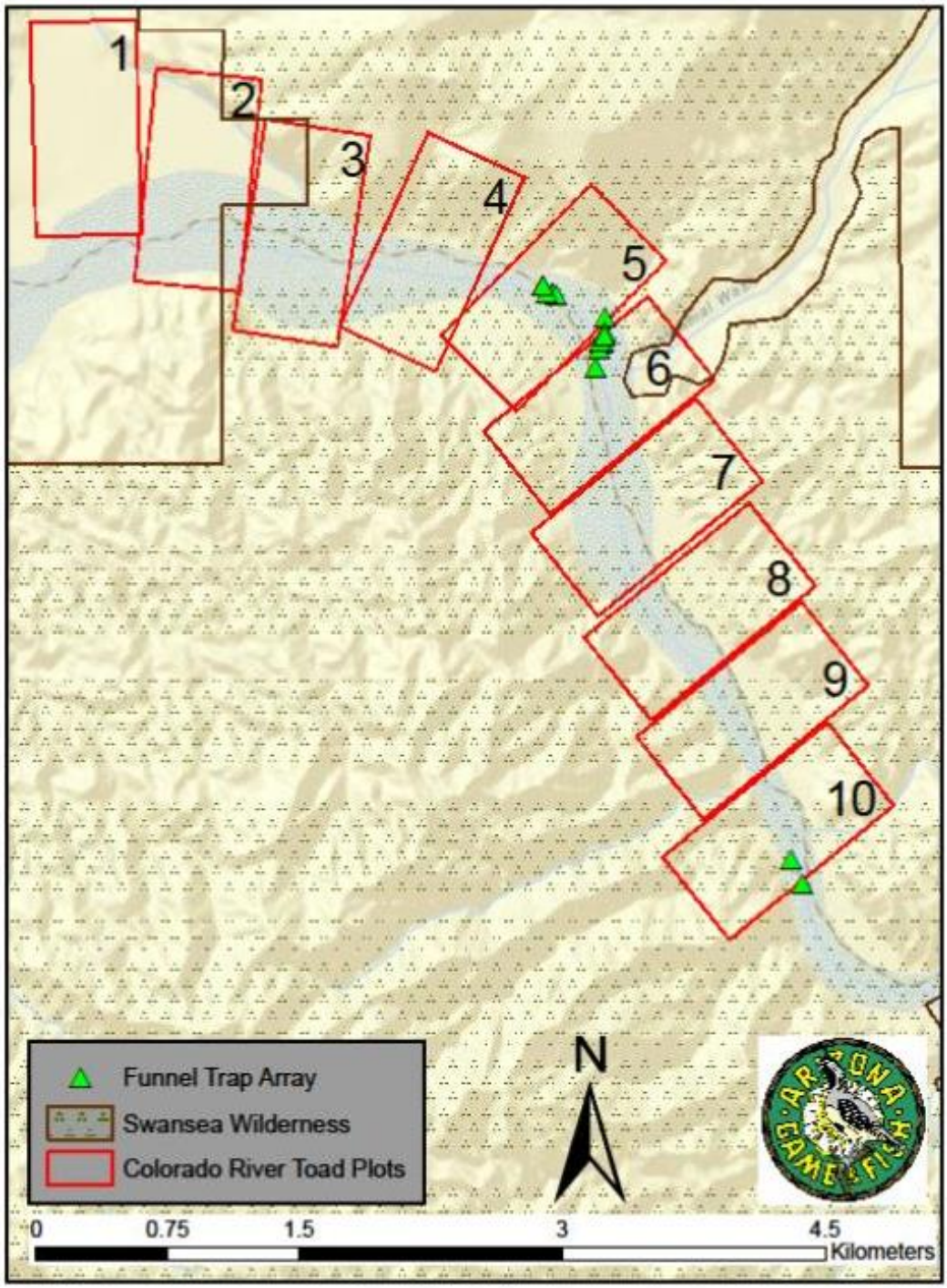

Figure 4.—Funnels trap locations on the BWR.
Green triangles represent trap locations.

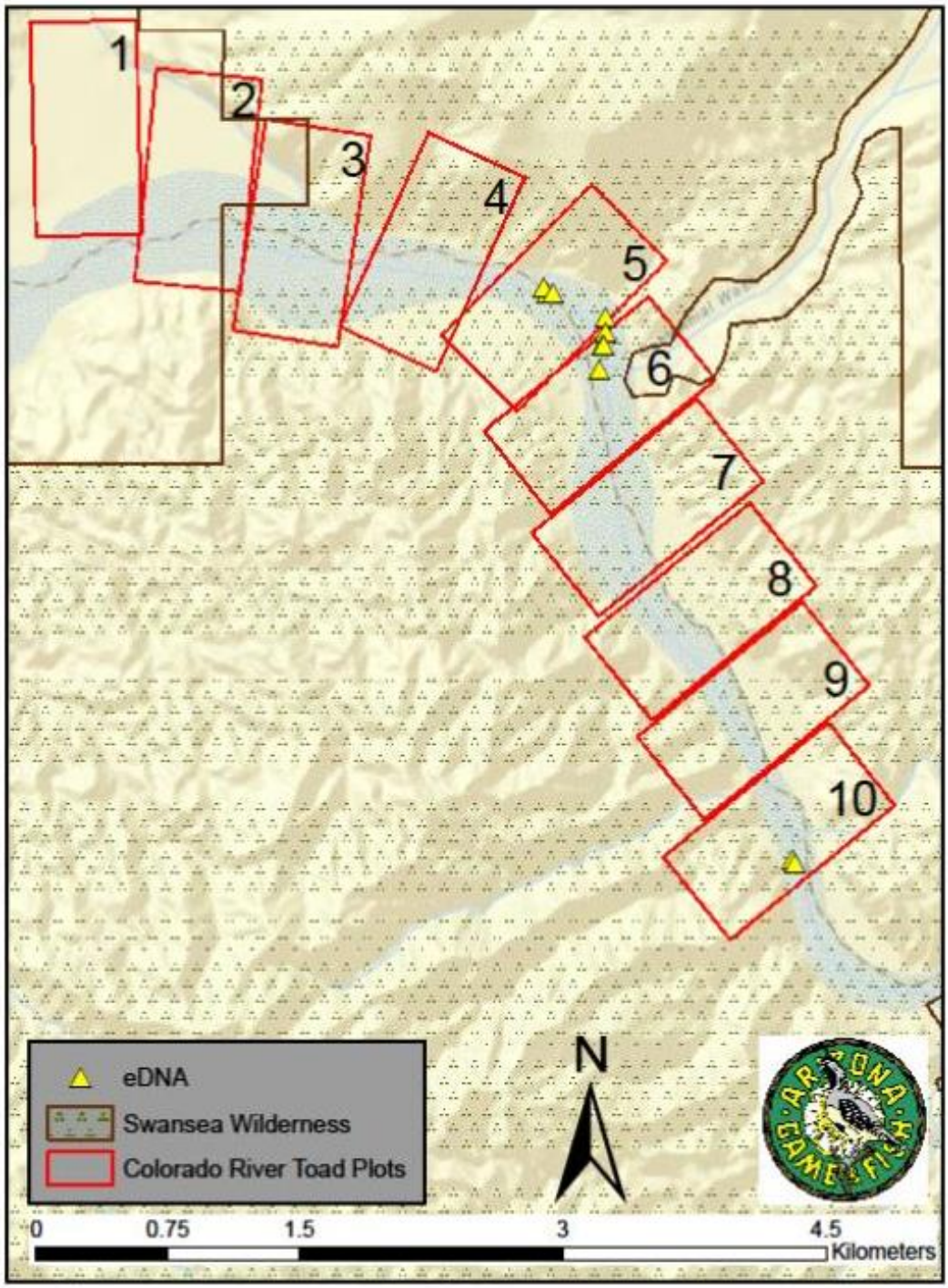

Figure 5.—eDNA collections on the BWR.
Yellow triangles represent sample locations.

Digital Automated Recorders

The DARs recorded CRTO calling on a total of 23 nights. All calling and breeding activity occurred between August 3, 2014, and September 17, 2014. DARs produced 84 detections of target species (table 1) of which 10 came from an incorrectly set recorder on plot 6 (table 2). Detections occurred from all plots except 7 and 8. The highest amount of detections came from plots 5, with 40 detections, and 6, with 24 detections, which included the incorrectly timed recordings. All other plots had six or less total detections. The hours with the highest detections were the 2300 and 0100 hours, which produced 16 detections each. The least amount of detections occurred during the 2100 hour, with four. Part of the detections came from a recorder on plot 6 that was not set correctly. It was believed that there was a 3-hour time difference on this set of detections in which the recorded time was actually set for Eastern Standard Time, and therefore, a 2100 recording was really a recording from 1800, 2200 was really 1900, 0000 was 2000, 0100 was 2100, and 0200 was 2200. Detections from this recording period, which were approximately 36 out of 87 nights, showed that the 2100 hour had the most detections, with four.

Table 1.—DAR detections per hour and per plot, excluding the incorrectly timed recordings from plot 6

Plot #	Time						Detections per plot
	21:00	22:00	23:00	00:00	1:00	2:00	
1	1	1	0	0	0	0	2
2	0	1	0	0	0	0	1
3	0	1	1	1	1	0	4
4	0	0	1	1	3	1	6
5	1	7	10	5	9	8	40
6	2	5	2	1	2	2	14
7	0	0	2	3	0	1	6
8	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0
10	0	0	0	0	1	0	1
Detections per hour	4	15	16	11	16	12	

Table 2.—Detections from incorrect recorder on plot 6 with corrected times

Estimated time						Total detections
18:00	19:00	20:00	21:00	22:00	23:00	
0	0	2	4	2	2	10

DISCUSSION

Visual Encounter and Call-Playback Surveys

VESs were effective in finding individual CRTO if surveys were conducted shortly after a monsoon event. Individuals were found foraging on nights when no monsoon activity occurred. However, on nights shortly after (approximately 2–5 days) a heavy monsoon event occurred, breeding pools were found, which enabled CRTO congregations to be located. Of the 11 detections, 5 occurred during a 2-night period (August 6 and 7, 2014) following a monsoon event when breeding occurred. The monsoon event occurred on August 3 and 4, 2014. Additionally, two amplectic pairs were incidentally observed on August 5, 2014, while hiking to the target plot, and this is reassurance that being present a few days after a heavy monsoon rain is ideal for finding toads. It is believed that all breeding activity, which includes calling, amplexus, or the location of an egg mass, occurred on plot 5 and 6. These two plots were the only ones to collect and maintain water for any length of time throughout the season. There are a few logistical constraints to this method: timing and person hours. A single VES occurs during a 2-hour period. As shown by the DAR recordings, activity begins near midnight. Many surveys started 1 hour prior to sunset, which in Arizona during summer months is between 1815 and 1930. This suggests that the nightly activity of CRTO may have been missed by being premature in VES timing.

Funnel Traps

Based on the limited results thus far, the use of funnel traps is the least effective survey method. Funnel traps, along with eDNA, both rely on biologists being onsite within a few days after a recent monsoon. This was an issue because when the water table is low in this system, as was the case in 2014, surface water does not persist long. Access to the study site was not possible on two occasions due to active monsoon rains. Damage from those rains to roadways made navigating the terrain challenging with the equipment. Water evaporating or percolating in 1 to 2 nights prevented trapping in potential breeding pools on additional plots. Water was probably available temporarily within the study area, other than at plots 5 and 6, corresponding with rain events, but the inability to get to the study site prevented confirmation of this. Successful breeding could not have occurred, regardless of any breeding activity, in these areas because the water did not persist

long enough. Finally, after one season of trapping, it appears that funnel traps are not adequate for collecting adult CRTO because the size of the opening is too small for them to enter. The main goal with this method was to catch tadpoles and/or metamorphosed toads, which were never caught. Several clusters of traps were set in areas where CRTO tadpoles and eggs were seen, and this shows the potential weakness of this particular method at catching the target species. Because the breeding activity for CRTO is relatively short, and significant rain events are so limited and unpredictable, the effectiveness of the funnel trap method has been hard to test. All the methods will be tested over a 3-year span; the effectiveness of this particular method could change over the next 2 years.

Environmental Deoxyribonucleic Acid (eDNA)

Like funnel traps, eDNA needs to be collected within a short timeframe after a monsoon event, as water may not persist long. Collection of eDNA is not as time sensitive as funnel traps. As long as there is some water in a plot, samples can be collected and still be viable. This method's limitation is that it can only be used to test for the presence of the target species, but it cannot give an estimate of population size. This method is not relying on physical detection but simply on an individual's presence in the water at some point in history. Because monsoon pools are recent, any deposit of genetic material would also be recent. Six samples were also not collected during the September 23 and 24, 2014, trap event, which reduced the total sample size.

Digital Automated Recorders

Detections from DARs were very high, specifically on plots 5 and 6. This is believed to be misleading, as one toad could have called all night and was therefore responsible for six detections. It was also determined that the detection range of the recorders overlapped with other recorders, which meant an individual was detected on two or more recorders. Many DAR detections overlapped in time and were adjacent to one another (table 3). All potential overlapping detections came from plots 4, 5, 6, and 7. Because of this, 28 total detections were reduced down to 13 detections. These potential duplications were analyzed heavily, and it was determined that the recorders could pick up adults calling from over 500 m away, meaning they were recorded on multiple devices. This changes the total detections from 84 individuals to 69 potential individuals. Finally, the recordings showed that calling of CRTO generally begins late at night, starting at 2100 hours and picking up at 2200 hours and continuing through 0200 hours with a maintained higher frequency. This information can influence the time at which the VESs start. It could also influence the start of recordings. It may be more beneficial to delay recordings by 1 hour to see if there are more detections in the

Table 3.—Potential overlapping detections of CRTR
(The first number is total number of individuals observed for the time period. The numbers in parentheses indicate the plot where the call was recorded.)

Time	8-Aug	10-Aug	13-Aug	14-Aug	15-Aug	28-Aug	29-Aug	30-Aug
21:00								
22:00		1 (5) 1 (6)	1 (5) 1 (6)					
23:00	1 (5) 1 (6)						1 (4) 1 (5)	
0:00		1 (5) 1 (6)						1 (4) 1 (5)
1:00				1 (5) 1 (6)		1 (4) 1 (5)	1 (4) 2 (5)	1 (4) 1 (5)
2:00		1 (5) 1 (6) 1 (7)			1 (5) 1 (6)	1 (4) 1 (5)		
Total	2	7	2	2	2	4	5	4

early morning hours as opposed to the early evening. Out of all four methods, even considering double counts, this method produced the highest amount of detections. Bridges and Dorcas (2000) suggest that this method can be beneficial for future monitoring of populations, and the results support this finding. This method does not require someone to be present to record valuable data. The recorders can be deployed at the beginning of the survey season and left until the end of the season and will automatically record data during any monsoon event that prevents someone from being onsite. They record every day, which cannot be said for any other method tested. Finally, it can be reasoned that within a 500-m square plot of suitable CRTO habitat, DARs can provide complete coverage of that area when male CRTO are calling.

Recorders do require large amounts of data storage capabilities. Throughout a season, an average of approximately 17.5 gigabytes of audio data are recorded. Over the course of 30 days, using 10 recording devices each collecting 6 minutes of audio a night, this project will result in the collection of approximately 6.6 gigabytes of audio.

A combination of VESs and DARs appear, thus far, to be the best methods for monitoring CRTO. Recorders are not able to detect females (as they don't make advertisement calls), breeding activity like amplexus, egg masses, tadpole success, or males that are not calling during dry periods, but VESs are able to make these detections. Surveys (VESs) of CRTO in the BWR from 2011 through 2013 found no breeding behavior, with the exception of one male that had fresh egg mass strands on its back (Cotten and Leavitt 2014). The DARs could have

missed this event simply because there was no calling detected by the biologists for this breeding event, which in turn shows the necessity for the biologists to actively conduct surveys as well. Prior to future deployments of DARs, the time on each unit should be synchronized to better asses duplicate calls across recorders. VESs provide a visual of the animal, the identification of potential or current breeding sites, and general activity, such as foraging, not associated with breeding behavior. The limitation of this method is time and man-hours. The inability to reach such remote locations after severe monsoon storms likely affected the detection of more individuals. Also, surveys generally start 1 hour prior to sunset, and toads may not be active until later hours, as the DAR results show. To increase the likelihood of detection probability, surveying after a monsoon event appears to produce the best results.

Habitat (*sensu*: Hall et al. 1997) is "the resources and conditions present in an area that produce occupancy – including survival and reproduction – by a given organism." Based on that definition, within the BWR study site, large portions of the plots that did not contain habitat for the target species were found. Survey plots were 500 x 1,000 m, but with the exception of plots 1 and 2, all other plots had a significant amount of steep mountainous terrain. Preferred habitat of CRTO is Sonoran desert scrub and more specifically the LCR desert scrub subdivision (Brennan and Holycross 2006). This biotic community consists of low elevation, flat, dry and sandy features dominated by creosote bush (*Larrea tridentata*), white bursage (*Ambrosia dumosa*), and desert salt bush (*Atriplex polycarpa*) (Brennan and Holycross 2006). The only portion of the study plots within this type of biotic community is the river and its historic flood plain represented by the blue within each plot (see figure 1). Plots 3–10 had between 20–60% of their surface areas covered with mountainous terrain. These areas of the plots were not surveyed due to the mountainous terrain that lacks suitable habitat traits for CRTO. As such, it is recommended that the plot width remain the same but that rocky steep sloping terrain be avoided during surveys so that the focus can be on suitable habitat.

A 2-hour survey period was originally set to give ample time to survey an entire plot during a VES. Survey periods could be shortened from 2 hours to 1.5 hours to reduce overall man-hours spent on each plot. A cost-benefit analysis will be conducted of the survey methods to determine the most cost-effective way to survey for CRTO. The addition of a weather station at the study site may aid in analyzing activity and breeding events associated with monsoon rains. Determining the exact date of a monsoon in this area is difficult unless someone is present onsite. Further tests of these methods will occur this coming year – first on the lowland leopard frog (*Lithobates yavapaiensis*) this spring and again on CRTO the following monsoon season.

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LITERATURE CITED

Adams, D.K. and A.C. Comrie. 1997. The North American monsoon. Bulletin of the American Meteorological Society 78:2197–2213.

Adang, T.C. and R.L. Gall. 1989. Structure and dynamics of the Arizona monsoon boundary. American Meteorological Society 117:1423–1438.

Brennan, T.C. and A.T. Holycross. 2006. A Field Guide to Amphibians and Reptiles in Arizona. Arizona Game and Fish Department Publication, Phoenix.

Bridges, A.S. and M.E. Dorcas. 2000. Temporal variation in anuran calling behavior: implications for surveys and monitoring programs. Copeia 2000:587–592.

Bureau of Reclamation (Reclamation). 2004. Lower Colorado River Multi-Species Conservation Program, Volume II: Habitat Conservation Plan, Final. December 17. Sacramento, California.

Cotten, T.B. 2011. Lowland Leopard Frog (*Rana yavapaiensis*) and Colorado River Toad (*Bufo alvarius*) Distribution and Habitat Use in the Greater Lower Colorado River Ecosystem: 2011 Annual Report. Submitted to the Bureau of Reclamation by the Arizona Game and Fish Department, Research Branch, Phoenix.

Cotten, T.B. and D. Grandmaison. 2012. Lowland Leopard Frog (*Rana yavapainsis*) and Colorado River Toad (*Bufo alvarius*) Distribution and Habitat Use in the Greater Lower Colorado River Ecosystem. Arizona Game and Fish Department, Contracts Branch, Flagstaff.

Cotten, T.B. and D.J. Leavitt. 2014. Lowland Leopard Frog and Colorado River Toad Distribution and Habitat Use in the Greater Lower Colorado River Ecosystem. Arizona Game and Fish Department, Contracts Branch, Phoenix.

Ficetola, F., C. Miaud, F. Pompanon, and P. Taberlet. 2008. Species detection using environmental DNA from water samples. Biology Letters 4:423–425.

Hall, L.S., P.R. Krausman, and M.L. Morrison.1997. The habitat concept and a plea for standard terminology. Wildlife Society Bulletin 25:173–182.

Heyer, W.R., M.A. Donnelly, R.W. McDiarmid, L.C. Hayer, and M.S. Foster (editors.). 1994. Measuring and monitoring biological diversity. Standards and methods for amphibians. Smithsonian Institution Press, Washington, D.C. 364 p.

Sullivan, B.K. and K.B. Malmos. 1994. Call variation in the Colorado River toad (*Bufo alvarius*): behavioral and phylogenetic implications. Herpetologica 50:146–156.

Sullivan, B.K. and P.J. Fernandez. 1999. Breeding activity, estimated age-structure, and growth in Sonoran Desert anurans. Herpetologica 55:334–343.