



Maintaining Frog Monitoring and Population on the Las Cienegas National Conservation Area

*Javan M. Bauder¹, Chris L. Prewitt²,
and David Hall²*

¹ U.S. Geological Survey, Arizona Cooperative Fish and Wildlife Research Unit

² University of Arizona

Cooperator Science Series # 167-2025

About the Cooperator Science Series:

The [Cooperator Science Series](#) was initiated in 2013. Its purpose is to facilitate the archiving and retrieval of research project reports resulting primarily from investigations supported by the [U.S. Fish and Wildlife Service \(FWS\)](#), particularly the [Wildlife and Sport Fish Restoration Program](#). The online format was selected to provide immediate access to science reports for FWS, state and tribal management agencies, the conservation community, and the public at large.

All reports in this series have been subjected to a peer review process consistent with the agencies and entities conducting the research. For U.S. Geological Survey authors, the peer review process (<http://www.usgs.gov/usgs-manual/500/502-3.html>) also includes review by a bureau approving official prior to dissemination. Authors and/or agencies/institutions providing these reports are solely responsible for their content. The FWS does not provide editorial or technical review of these reports. Comments and other correspondence on reports in this series should be directed to the report authors or agencies/institutions. In most cases, reports published in this series are preliminary to publication, in the current or revised format, in peer reviewed scientific literature. Results and interpretation of data contained within reports may be revised following further peer review or availability of additional data and/or analyses prior to publication in the scientific literature.

The [Cooperator Science Series](#) is supported and maintained by the FWS, [National Conservation Training Center](#) at Shepherdstown, WV. The series is sequentially numbered with the publication year appended for reference and started with Report No. 101-2013. Various other numbering systems have been used by the FWS for similar, but now discontinued report series. Starting with No. 101 for the current series is intended to avoid any confusion with earlier report numbers.

The use of contracted research agencies and institutions, trade, product, industry or firm names or products or software or models, whether commercially available or not, is for informative purposes only and does not constitute an endorsement by the U.S. Government.

Contractual References:

This document (USGS IPDS #: IP-172427) was developed in conjunction with the University of Arizona and the Arizona Cooperative Fish and Wildlife Research Unit (U.S. Geological Survey, Arizona Game and Fish Department, the University of Arizona, U.S. Fish and Wildlife Service and Wildlife Management Institute cooperating). Funding was provided by a grant to J. Bauder from Department of Interior, U.S. Bureau of Land Management (Grant L20AC00273-5). This work was conducted under permits from the U.S. Fish and Wildlife Service (TE02234C and ESPER0033846), Arizona Game and Fish Department (SP410389), and the University of Arizona Institutional Animal Care and Use Committee (2022-0871).

Recommended citation:

Bauder, J.M, Chris L. Prewitt and D. Hall. 2025. Maintaining Frog Monitoring and Population on the Las Cienegas National Conservation Area. U.S. Department of Interior, Fish and Wildlife Service, Cooperator Science Series FWS/CSS-167-2025, Washington, D.C.
<https://doi.org/10.3996/10.3996/css46271852>

For additional copies or information, contact:

Javan Bauder
U.S. Geological Survey
Arizona Cooperative Fish and Wildlife Research Unit
University of Arizona
Tucson, AZ 85721
mail: jbauder@usgs.gov

Final Report: Maintaining Frog Monitoring and Population on the Las Cienegas National Conservation Area

Final Report for Grant L20AC00273-5

Javan M. Bauder¹, Chris L. Prewitt², and David Hall³

¹ U.S. Geological Survey, Arizona Cooperative Fish and Wildlife Research Unit, Tucson, AZ

² Arizona Cooperative Fish and Wildlife Research Unit, University of Arizona, Tucson, AZ

³ School of Environment and Natural Resources, University of Arizona, Tucson, AZ



Las Ciénegas National Conservation Area (*photo: Javan Bauder*)

Executive Summary

This report summarizes and analyzes the data collected on the Chiricahua Leopard Frog (CLF) populations on the Las Ciénegas National Conservation Area (LCNCA) in southeast Arizona, U.S.A., during the reporting period covered under this funding agreement from September 2020 through October 2024 and place this analysis in historical context of the previous monitoring efforts. The major findings of this report are:

1. We conducted a total of 465 surveys across 46 sites on the LCNCA and the associated Elgin Buffer Zone during September 2020 through October 2024. We conducted 323 surveys across the 19 core CLF monitoring sites on the LCNCA and 112 surveys across 13 core buffer zone sites.
2. We detected CLF at each of our 19 core LCNCA monitoring sites during at least one year in which we conducted surveys across the year's entire field season (i.e., 2021-2024). We detected CLF reproduction in each of these four years at four sites and suspected reproduction to have occurred during all four years at a fifth site. We did not detect CLF reproduction at seven of these 19 core monitoring sites during the report period. We assisted with six CLF translocations to sites on the LCNA during the report period.
3. Site occupancy rates across the LCNCA during the report period remain consistent with those reported during previous years and continue to indicate the presence of a stable CLF metapopulation within the LCNCA.
4. Monitoring efforts in the Elgin Buffer Zone continue to be successful at preventing reinvasion by invasive American bullfrogs to the LCNCA. We detected and removed bullfrogs from three sites in the Elgin Buffer Zone and no bullfrogs were detected during 2024. The LCNCA continues to remain bullfrog free since 2017.

Table of Contents

Introduction.....	4
Study Area(s)	6
Figure 1. Chiricahua leopard frog (CLF) monitoring sites and Elgin Buffer Zone sites on and around the Las Ciénegas National Conservation Area (NCA) in southeast Arizona.....	8
Figure 2. Chiricahua leopard frog (CLF) monitoring sites along Cienega Creek and its tributaries on the Las Ciénegas National Conservation Area (NCA) in southeast Arizona.....	10
Table 1. Summary of survey effort and results by year of Chiricahua leopard frog (CLF) monitoring sites on the Las Ciénegas National Conservation Area during September 2020 through October 2024.	11
Table 2. Summary of survey effort and results by year of American bullfrog (ABF) surveys within the Elgin Buffer Zone on and around the Las Ciénegas National Conservation Area during September 2020 through October 2024.	13
Methods	14
Table 3. Starting and ending coordinates for lotic sites along Cienega Creek and its tributaries at the Las Ciénegas National Conservation Area during September 2020 through October 2024.....	15
Results.....	17
LCNCA Sites	18
Figure 3. Detections of Chiricahua leopard frogs (CLF) and CLF reproduction across monitoring sites on the Las Ciénegas National Conservation Area (LCNCA) during September 2020 through October 2024.	19
Figure 4. Number of years by site where Chiricahua leopard frog (CLF) reproduction was detected on the Las Ciénegas National Conservation Area (LCNCA) during 2021 through 2024.....	20
Table 4. Descriptions of Chiricahua leopard frog translocation events on the Las Ciénegas National Conservation Area during September 2020 through October 2024.....	21
Elgin Buffer Zone Sites.....	22
Other Native Herpetofauna	22
Figure 5. Number of sites on the Las Ciénegas National Conservation Area where Chiricahua leopard frogs (CLF) were detected during 2010 through 2024.....	23
Discussion	24
Acknowledgments.....	28
Literature Cited	29

Introduction

The Chiricahua leopard frog (*Rana (Lithobates) chiricahuensis*, hereafter CLF) is a federally threatened amphibian that is native to Arizona, New Mexico, and the Mexican states of Sonora and Chihuahua (U. S. Fish and Wildlife Service 2007). The CLF has declined throughout its range due to the loss and degradation of native riparian and wetland habitats, direct and indirect impacts from nonnative species, and disease, particularly the fungal disease *Batrachochytrium dendrobatidis* (Bd) (Rosen and Schwalbe 1995, Sredl and Jennings 2005, U. S. Fish and Wildlife Service 2007). One nonnative species that has had a particularly detrimental impact on CLF is the American bullfrog (*Rana (Lithobates) catesbeiana*, hereafter bullfrogs). Bullfrogs are widespread throughout southeast Arizona and have the potential to negatively affect CLF and other native herpetofauna through direct predation and as vector of disease, including Bd (Rosen and Schwalbe 1995, U. S. Fish and Wildlife Service 2007, Hossack et al. 2023). Bullfrogs are able to occupy a wide range of permanent aquatic habitats, including highly modified or degraded environments, and are capable of dispersing up to 10 km in arid Southwestern landscapes (Suhre 2010) which allows them to readily invade unoccupied habitats. Furthermore, bullfrogs have extremely high reproductive potential and can reach high local population densities thereby allowing them to quickly dominate aquatic environments (Bury and Whelan 1985). As a result of the threats posed to CLF by bullfrogs, bullfrog eradication has been identified as an important component to CLF recovery (U. S. Fish and Wildlife Service 2007, Jarchow et al. 2016, Hossack et al. 2023).

Beginning in 2010, a coalition including the University of Arizona (UA), the Ciénega Watershed Partnership (CWP), Bureau of Land Management (BLM) and private citizens formed the Frog Project with the goal of restoring aquatic habitats on the BLM's Las Ciénegas National

Conservation Area (LCNCA). The LCNCA encompasses a relatively large, intact grassland landscape with a perennial Cienega stream (i.e., Cienega Creek) wetland complex that represents an important habitat feature for native aquatic species. Historical (1970s through early 2000s) CLF records are present for the LCNCA but CLF populations declined markedly in this area such that by the early-mid 2000s CLF reproduction was documented at only a single site on the LCNCA (Empire Gulch Spring; Rosen et al. 2012). A primary goal of this project was to restore aquatic habitat for CLF by removing bullfrogs and creating additional permanent water bodies (Rosen et al. 2013). This effort was successful in meeting these recovery goals, and no bullfrogs have been detected on the LCNCA since 2017. Efforts to keep the LCNCA free of bullfrogs have benefited from the establishment of the Elgin Buffer Zone on and around the LCNCA. Aquatic habitats (e.g., stock tanks) within this buffer zone are monitored annually to detect and remove bullfrogs before they can reinvade the LCNCA. Following bullfrog removal, a combination of CLF translocations and natural CLF dispersal resulted in the presence of an apparently robust CLF metapopulation on LCNCA (Rosen et al. 2013, Hall 2019). Monitoring efforts have confirmed the continued presence of Bd among CLF sites within LCNCA which causes seasonal winter die-offs (Hall 2015). However, CLF still persist on the LCNCA in the face of Bd die-offs because CLF tadpoles are not substantially impacted by Bd and late-season tadpoles will overwinter and metamorphose and reproduce the following year (Hall 2015; 2019). The recovery of CLF on the LCNCA highlights the importance of continued monitoring of this CLF metapopulation.



Chiricahua leopard frog adult from Headwaters at the LCNCA. *(photo by Javan Bauder)*

In this report, we summarize the results of CLF monitoring and bullfrog removal efforts in the LCNCA and Elgin Buffer Zone from September 2020 through October 2024 which was funded under BLM agreement L20AC00273-5. Our objectives were to: 1) report the number of sites where CLF were detected and where CLF reproduction was detected by year, and 2) describe the results of bullfrog removal efforts including the number of sites by year where bullfrogs were detected and removed.

Study Area(s)

Our survey sites included sites on the LCNCA and its associated buffer zone, the Elgin Buffer Zone (Figure 1). The Las Ciénegas National Conservation Area was established in 2000

and consists of approximately 170 km² of semidesert grasslands, riparian gallery forests, marshlands, and mesquite (*Prosopis* spp.) bosques (i.e., woodlands) (Brown 1994). Cattle grazing occurs throughout the LCNCA. Cienega Creek runs south to north through the LCNCA and supports riparian gallery forests consisting primarily of Fremont cottonwood (*Populus fremontii*), Goodding willow (*Salix gooddingii*), seep willow (*Baccharis salicifolia*), netleaf hackberry (*Celtis reticulata*), and desert elderberry (*Sambucus nigra*). Herbaceous vegetation within riparian environments includes cattail (*Typha* spp.), sedge (*Eleocharis* spp.), bulrush (*Scirpus* spp.), rush (*Juncus* spp.), yerba mansa (*Anemopsis californica*), watercress (*Nasturtium officinale*), wild mint (*Mentha arvensis*), and duckweed (*Lemna* spp.). Seven of our survey sites are along Cienega Creek or its tributaries (Figure 2). These sites consist of multiple geomorphological features including perennial pools up to 3 m deep, glides, riffles and shallow runs. Uniquely among most, if not all, southwestern riparian environments, Cienega Creek supports only native fishes including Gila topminnow (*Poeciliopsis occidentalis*), Gila chub (*Gila intermedia*), and longfin dace (*Rhinichthys chrysogaster*) (Rosen et al. 2012). Cienega Creek also supports lowland leopard frogs (*Rana (Lithobates) yavapaiensis*) and federally threatened northern Mexican gartersnakes (*Thamnophis eques*). The Elgin Buffer Zone runs along the length of Arizona Highway 82 from the eastern side of the community of Sonoita, Arizona to a midpoint between the Mustang and Whetstone Mountains in Rain Valley.

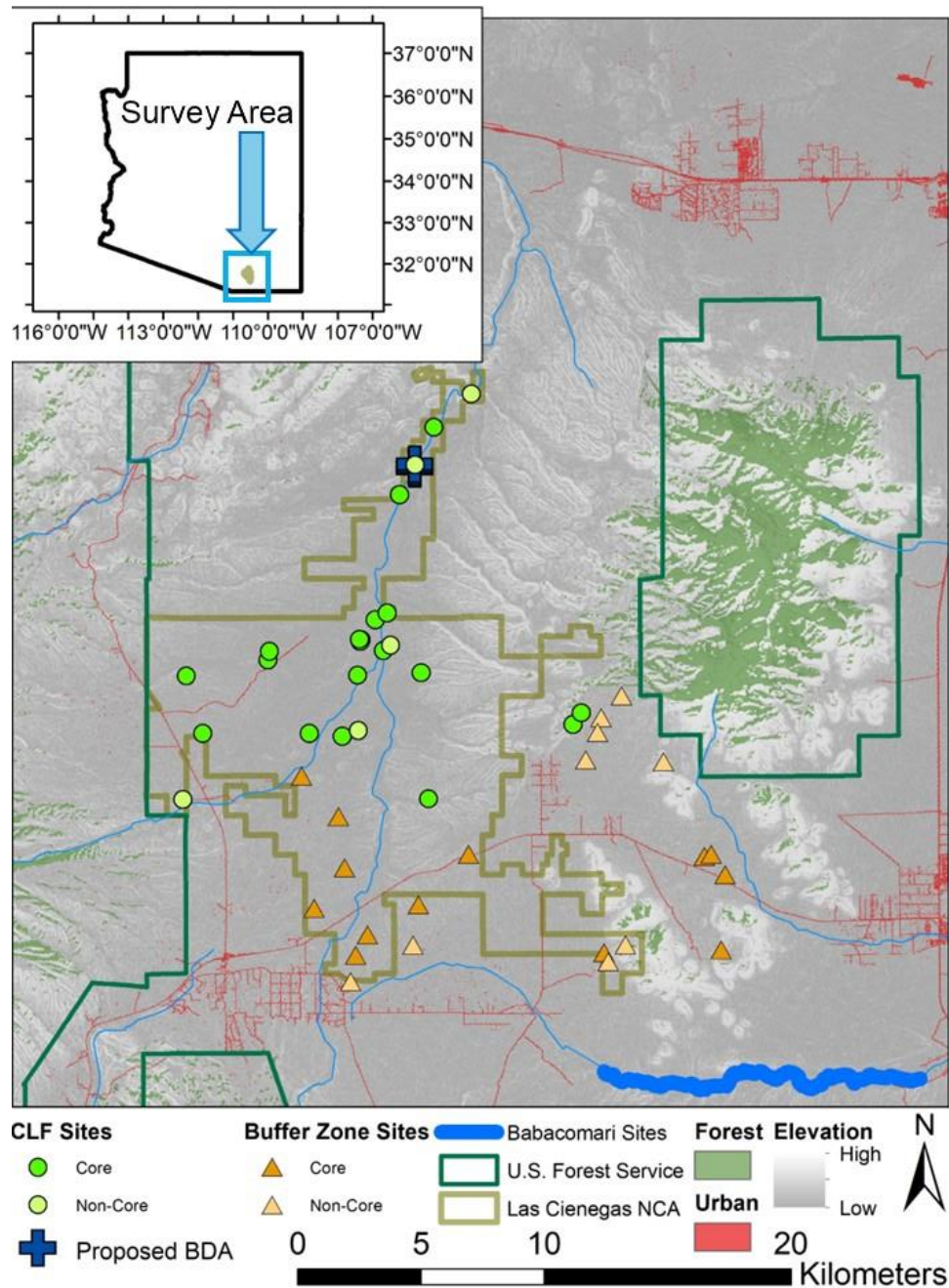


Figure 1. Chiricahua leopard frog (CLF) monitoring sites and Elgin Buffer Zone sites on and around the Las Ciénegas National Conservation Area (NCA) in southeast Arizona.

Core sites of primary CLF monitoring focus include 19 sites within the LCNCA (darker green circles) and core sites of primary bullfrog monitoring focus include 13 sites within the Elgin Buffer Zone (darker orange triangles). The Babacomari Sites are the focus of ongoing American bullfrog eradication efforts. Inset map shows the location of our survey area within the state of Arizona. Proposed BDA are proposed locations of beaver dam analogs that are planned to be installed during December 2024.

Our monitoring sites include lotic sites along Cienega Creek and its tributaries (Empire Gulch and Mattie Canyon) and multiple lentic sites within the LCNCA and Buffer Zone. Most lentic sites are human-created water structures. Clyne Spring is a natural spring-fed lentic site within an ephemeral wash and Cinco Wetlands is also a natural lentic site. Human-created ponds were constructed to provide water sources for cattle and/or wildlife. Several ponds (i.e., wildlife ponds, hereafter W.P.) on the LCNCA have solar or power-line powered wells to maintain standing water. All other ponds, particularly those in the Elgin Buffer Zone, are filled by runoff and may not hold standing water during drought conditions. Vegetation levels at ponds vary widely from virtually no vegetation to near complete surface coverage of floating vegetation (primarily duckweed, pondweed [*Potamogeton* spp.], and/or algae). Perimeter vegetation at ponds can include willow, cattail, sedge, bulrush, rush, and other grasses and forbs. Sites on the LCNCA are generally more vegetated compared to sites within the Elgin Buffer Zone (mean and range of percent perimeter vegetation is 90% [0–100%] and 16% [0–100%], respectively). Elevations across all our sites ranged from 1282–1593 m. We focused our efforts on 19 CLF sites on the LCNCA that have been the focus on long-term monitoring and/or restoration efforts (Rosen et al. 2013, Hall 2021). We conducted periodic surveys at an additional five sites on the LCNCA (Table 1). Within the Elgin Buffer Zone, we focused our efforts on 13 buffer zones (Hall 2021) while conducting periodic surveys at an additional nine sites within the Elgin Buffer Zone (Table 2).

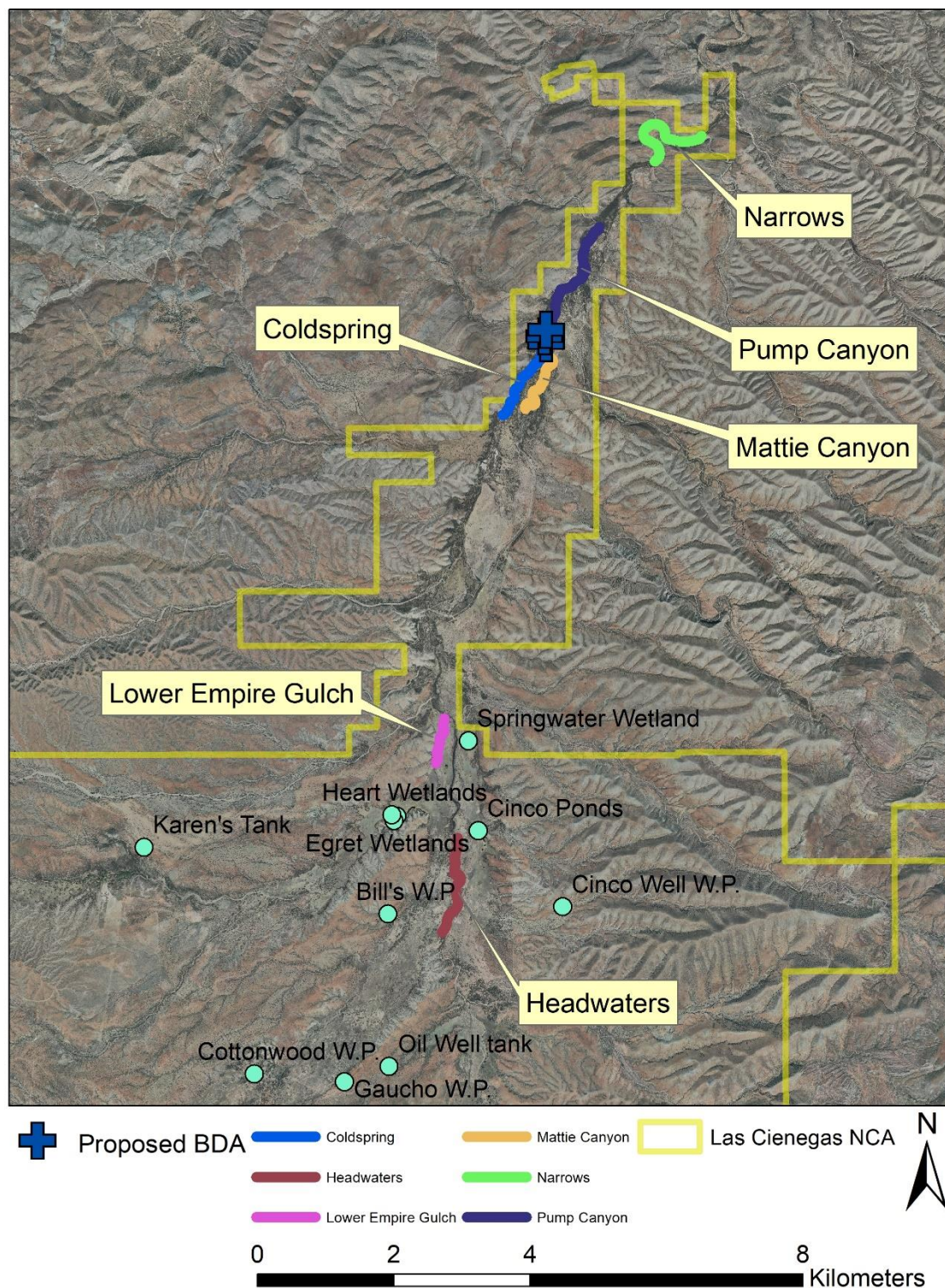


Figure 2. Chiricahua leopard frog (CLF) monitoring sites along Cienega Creek and its tributaries on the Las Ciénegas National Conservation Area (NCA) in southeast Arizona. Proposed BDA are proposed locations of beaver dam analogs that are planned to be installed during December 2024.

Table 1. Summary of survey effort and results by year of Chiricahua leopard frog (CLF) monitoring sites on the Las Ciénegas National Conservation Area during September 2020 through October 2024. Results are summarized by calendar year with the exception of 2020 which only includes results beginning in September 2020. UTM coordinates are in NAD83 Zone 12N. Column names denote the year (20 = 2020, 21 = 2021, 22 = 2022, 23 = 2023, 24 = 2024), the number of surveys (S) per year, and if CLF were detected reproducing (R), present but no reproduction detected (P), or no CLF were detected (A). NA indicates the site was not surveyed that year. The number of years during 2021–2024 where CLF were detected (including reproduction) and where CLF reproduction was detected are denoted by Years P. and Years R., respectively. *denotes a site that received translocated CLF that year.

Site	UTM x	UTM y	Type	S20 ²	CLF20 ²	S 21	CLF 21	S 22	CLF 22	S 23	CLF 23	S 24	CLF 24	Years P.	Years R.
Bill's W.P	537982	3516405	lentic	1	P	7	R	6	R	5	R	5	R ³	4	3 ³
Cinco Well W.P.	540544	3516508	lentic	1	P	7	R	7	P	7	P*	4	P	4	4
Clyne Pond	546714	3514423	lentic	1	P	2	P	2	P	4	R	5	P	4	1
Clyne Spring	547045	3514876	lentic	1	P	2	P	1	A	1	P	1	A	4	1
Coldspring	539671	3523726	lotic	1	P	2	P	3	P	3	P	6	P	2	0
Cottonwood W.P.	536020	3514060	lentic	1	P	6	R	5	R	5	R	5	R	4	0
Crescent Wetland	538110	3517840	lentic	NA	NA	1	R	3	R	4	P	5	P	4	4
Egret Wetland	538073	3517773	lentic	NA	NA	1	P	3	P	4	P	5	A	4	2
Empire Gulch Spring	534339	3517030	lotic	1	P	2	R	5	R	4	P	5	P	3	0
Empire Well W.P.	531033	3516382	lentic	1	P	5	R	5	R	7	R	5	R	4	2
Gaucha W.P.	537345	3513945	lentic	1	A	8	R*	5	R	5	R	5	R	4	4
Headwaters	539019	3517416	lotic	1	R	5	R	2	R	3	R	4	P	4	4
Heart Wetland	538043	3517859	lentic	NA	NA	1	P	3	P	4	P	5	P	4	3
Karen's Tank	534403	3517385	lentic	1	A	4	A	5	P*	3	A	5	P	4	0
Lower Empire Gulch	538695	3518657	lotic ⁴	NA	NA	1	P	4	R	4	R	8	R	2	0
Maternity Well W.P.	531700	3514054	lentic	NA	NA	6	R*	4	R	6	R	6	R	4	3

Pump Canyon	541072	3526464	lotic	NA	NA	1	P	3	A	3	A	4	P	4	4
Road Canyon W.P.	540859	3511398	lentic	1	P	5	P	4	P*	5	A	3	A	2	0
Springwater Wetland	539161	3518944	lentic	NA	NA	NA	NA	3	R	4	R	5	P	2	0
Cinco Wetlands ¹	539308	3517626	lentic	NA	NA	NA	NA	1	A	NA	NA	NA	NA	3	2
Mattie Canyon ¹	540306	3524938	lotic	NA	NA	NA	NA	NA	NA	1	A	NA	NA	0	0
Narrows ¹	542585	3527814	lotic	NA	NA	NA	NA	NA	NA	NA	NA	4	A	0	0
Oil Well Tank ¹	537999	3514171	lentic	NA	NA	1	A	NA	NA	NA	NA	NA	NA	0	0
Sycamore Grove Tank ¹	530885	3511372	lentic	NA	NA	1	A	NA	NA	NA	NA	2	P	0	0
<i>Number of core sites where CLF were detected</i>							17		17		16		17		
<i>Number of core sites where CLF reproduction was detected</i>							9		10		9		6 ³		

¹Not part of the core 19 monitoring sites

²Surveys during 2020 were only conducted from 18–25 September

³Reproduction was suspected but not confirmed. No CLF were observed during March and early June surveys but 33 adult CLF 65-70 mm snout-vent length were observed on 18 July 2024. We suspect that these adults metamorphosed during the 2024 pre-monsoon summer.

⁴Functions more as a lentic site despite being within Cienega Creek

Table 2. Summary of survey effort and results by year of American bullfrog (ABF) surveys within the Elgin Buffer Zone on and around the Las Ciénegas National Conservation Area during September 2020 through October 2024. Results are summarized by calendar year with the exception of 2020 which only includes results beginning in September 2020. UTM coordinates are in NAD83 Zone 12N. Column names denote the year (20 = 2020, 21 = 2021, 22 = 2022, 23 = 2023, 24 = 2024), the number of surveys (S) per year, and if ABF were (P) or were not detected (A). NA indicates the site was not surveyed that year. Core denotes if a site was part of the 13 core buffer zone sites. No ABF bullfrog reproduction was detected at any of these sites.

Site	x	y	S20	RACA20	S21	RACA21	S22	RACA22	S23	RACA23	S24	RACA24	Core
Beck Tank	536214	3506957	NA	NA	NA	NA	4	A	2	A	4	A	Core
BZ 1	542477	3509152	NA	NA	NA	NA	2	A	NA	NA	NA	NA	Core
BZ 10	552890	3508322	NA	NA	4	P	5	A	3	A	5	A	Core
BZ 11	552038	3509073	NA	NA	2	A	3	A	2	A	4	A	Core
BZ 2	552314	3509152	NA	NA	1	A	4	A	1	A	4	A	Core
Dry Tank	538377	3505886	NA	NA	1	A	2	A	NA	NA	NA	NA	Core
Home Tank	537903	3505060	NA	NA	1	A	4	A	2	A	5	A	Core
Jack Daniels Dam	547974	3505155	NA	NA	NA	NA	3	A	4	P	7	A	Core
Johnson Tank	537207	3510687	NA	NA	NA	NA	2	A	1	A	4	A	Core
Little Tank	537447	3508608	NA	NA	NA	NA	2	A	NA	NA	1	A	Core
Mill pond	540445	3507108	NA	NA	1	A	3	A	NA	NA	NA	NA	Core
Mustang Dam	552730	3505274	NA	NA	2	P	4	P	4	A	5	A	Core
Reggie Tank	535708	3512324	NA	NA	NA	NA	2	A	NA	NA	2	A	Core
BLM Slattum	540235	3505464	NA	NA	NA	NA	1	A	NA	NA	NA	NA	Non-Core
Dry Jack Tank	548151	3504790	NA	NA	NA	NA	NA	NA	1	A	NA	NA	Non-Core
Goat Well	550384	3512901	NA	NA	NA	NA	NA	NA	NA	NA	1	A	Non-Core
Hospital Tank	547227	3512978	NA	NA	NA	NA	NA	NA	4	A	5	A	Non-Core
Jim Davis Pond	537700	3503985	NA	NA	1	P	NA	NA	NA	NA	NA	NA	Non-Core
Little Jack Daniels Tank	548849	3505482	NA	NA	NA	NA	NA	NA	1	A	NA	NA	Non-Core
McNalley Tank	548683	3515584	NA	NA	NA	NA	NA	NA	NA	NA	1	A	Non-Core
State Tank	547860	3514697	NA	NA	NA	NA	NA	NA	NA	NA	2	A	Non-Core
Sues Pond	547716	3514102	1	A	NA	NA	NA	NA	NA	NA	2	A	Non-Core

Methods

We conducted nighttime visual encounter surveys (VES) at each site following the CLF Recovery Plan (U. S. Fish and Wildlife Service 2007). Observers carefully approached each site scanning with binoculars or flashlights, listened for calling amphibians, and then proceeded to walk near the edge of the water to detect amphibians. Amphibians were detected by direct observation or by hearing them jump into the water. We periodically used dip-netting and seining for tadpoles to determine if reproduction had occurred at a site. Some sites were visited less frequently than others due to low water levels, weather, fire or scheduling constraints. For our lotic sites along Cienega Creek and its tributaries (Narrows, Pump Canyon, Coldspring, Lower Empire Gulch, and Headwaters), we conducted surveys along the same survey reach within each site (Table 3) although the amount of aquatic environments survey varied across surveys depending on precipitation and seasonal flow levels.

Table 3. Starting and ending coordinates for lotic sites along Cienega Creek and its tributaries at the Las Ciénegas National Conservation Area during September 2020 through October

2024. UTM coordinates are in NAD83 Zone 12N. Coordinates reflect the maximum extent of the survey reach during this study although inter-survey variation in start/end coordinates occurred and generally was minor in nature (e.g., due to inter-observer variation in the precision location where the GPS reading was taken) although the reach surveyed was occasionally less during a given survey due to time or other logistical constraints.

Site	Start x	Start y	End x	End y
Narrows	542585	3527814	541903	3527438
Pump Canyon	541079	3526465	540291	3524922
Coldspring	539669	3523727	540299	3524922
Mattie Canyon	540306	3524938	539994	3523803
Lower Empire Gulch	538681	3518612	538811	3519274
Headwaters	539007	3517525	538767	3516132

During each survey, we recorded the date, survey start and end time, and estimated site width (m) and length (m) visually or using a rangefinder, measured ambient temperature (C°) and relative humidity using a Kestrel pocket weather meter, measured water temperature (C°) and water pH using a Hanna Combo pH & EC meter, and estimated the percent cover of floating vegetation, submerged vegetation, perimeter vegetation, and emergent vegetation. We recorded the total number of wetland-associated reptiles and amphibians detected by life stage (adult, juvenile, larvae, egg masses). We considered CLF with snout-vent length ≥ 60 mm to be adults based on previous mark-recapture surveys at the LCNCA (D. Hall, unpublished data) and we ensured that our field crews were able to visually estimate the SVL and associated life stage of post-metamorphic CLF. All survey data were recorded on the CLF/Riparian Herpetofauna VES

Datasheet version 2.5 (Arizona Game and Fish Department, February 2020). We performed periodic CLF translocations in consultation with Arizona Game and Fish Department, U.S. Fish and Wildlife Service, and Bureau of Land Management to restore CLF at sites not occupied by CLF during previous years and/or to augment existing CLF populations. We translocated either CLF egg masses or juveniles collected in situ from nearby sites with CLF present.

We used the aforementioned survey protocols when surveying sites within the Elgin Buffer Zone with the primary focus being to detect and remove bullfrogs. We removed any bullfrogs we detected. When possible, we assigned all bullfrogs to a size class using visually estimated or measured snout-vent length. We allocated additional survey efforts to sites where bullfrogs were known to occur or had been observed during previous years to minimize opportunities for bullfrog reproduction.

We conducted surveys across all sites from March through October of each year. Within this report, we therefore summarized the number of sites where CLF were detected or where CLF reproduction was detected by calendar year for 2021–2024. We note that this report only covers the last two months of the 2020 survey season (September and October) and we refer readers to earlier reports for detailed discussions of survey results during and prior to 2020 (Hall 2015; 2019; 2021). We considered CLF to have reproduced at a site during a given year if we detected eggs or tadpoles or juvenile (i.e., metamorph) frogs prior to the onset of the year's monsoon rains (i.e., June or earlier). This ensured that the presence of juveniles was not the result of monsoon-induced dispersal. Because CLF tadpoles on the LCNCA can overwinter and metamorphose the following year, there were situations where the presence of relatively large CLF tadpoles early in the year (e.g., March) were considered to indicate reproduction the previous year. For example, we detected CLF tadpoles in Lower Empire Gulch on 22 March

2023 but considered those tadpoles to have hatched in 2022 and therefore considered reproduction to have occurred during 2022 at this site.



Juvenile CLF translocated at the LCNCA. (*photo by Chris Prewitt*)

Results

We conducted 465 monitoring surveys across 46 sites on the LCNCA and the Elgin Buffer Zone during September 2020 through October 2024 (Tables 1 & 2). We conducted a total of 333 surveys during this time across all sites considered as part of our LCNCA monitoring plan, 321 of which were conducted during full field seasons (i.e., March through October) during 2021-2024 (Table 1). We conducted a total of 132 surveys during this time across sites within the Elgin Buffer Zone, 131 of which were conducted during full field seasons (i.e., March

through October) during 2021-2024 (Table 2). Because this report period covers only the end of the 2020 field season, we primarily restrict our discussion to survey results from 2021-2024.

LCNCA Sites

Within our core 19 CLF monitoring sites on the LCNCA, we conducted 323 surveys across the entire reporting period, 311 of which were conducted during 2021–2024. We detected CLF at each site during at least one of our four complete monitoring seasons (2021, 2022, 2023, and 2024; Figure 3). We detected CLF during all four of our complete monitoring seasons at 13 sites (four lotic and nine lentic sites). We detected CLF at two sites during three of these four years and at four sites during two of these four years (Table 1). We detected CLF reproduction during at least one of our four complete monitoring seasons in 12 of these 19 sites. We never detected CLF reproduction at seven sites, three lotic sites along Cienega Creek (Clyne Spring, Coldspring, and Pump Canyon) and four lentic (Egret Wetlands, Heart Wetlands, Karen’s Tank, and Road Canyon W.P.). We detected CLF reproduction during all four of our complete monitoring seasons at four sites (Empire Well W.P., Gaucho W.P., Cottonwood W.P., and Maternity Well W.P.; Table 1) although at a fifth site, Bill’s W.P., reproduction was suspected to have occurred during a fourth year (2024; Table 1, Figure 4). We detected CLF reproduction at three sites (including Bill’s W.P.) during three of these four years, at three sites during two of these four years, and at two sites during one of these four years (Table 1). We conducted a total of 10 surveys at five other LCNCA sites not considered part of our core monitoring sites (Table 1). No CLF were detected at these five sites.

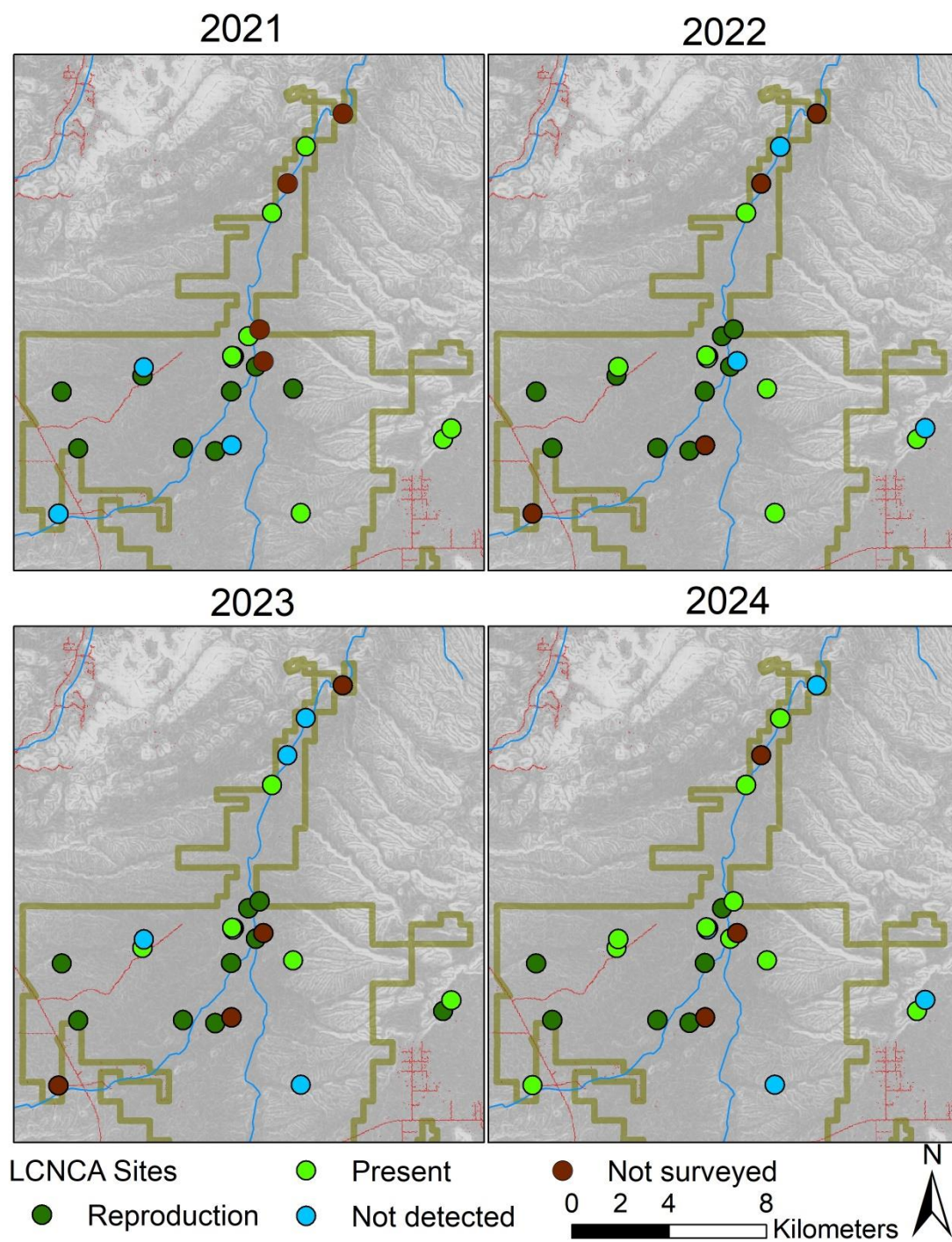


Figure 3. Detections of Chiricahua leopard frogs (CLF) and CLF reproduction across monitoring sites on the Las Ciénegas National Conservation Area (LCNCA) during September 2020 through October 2024.

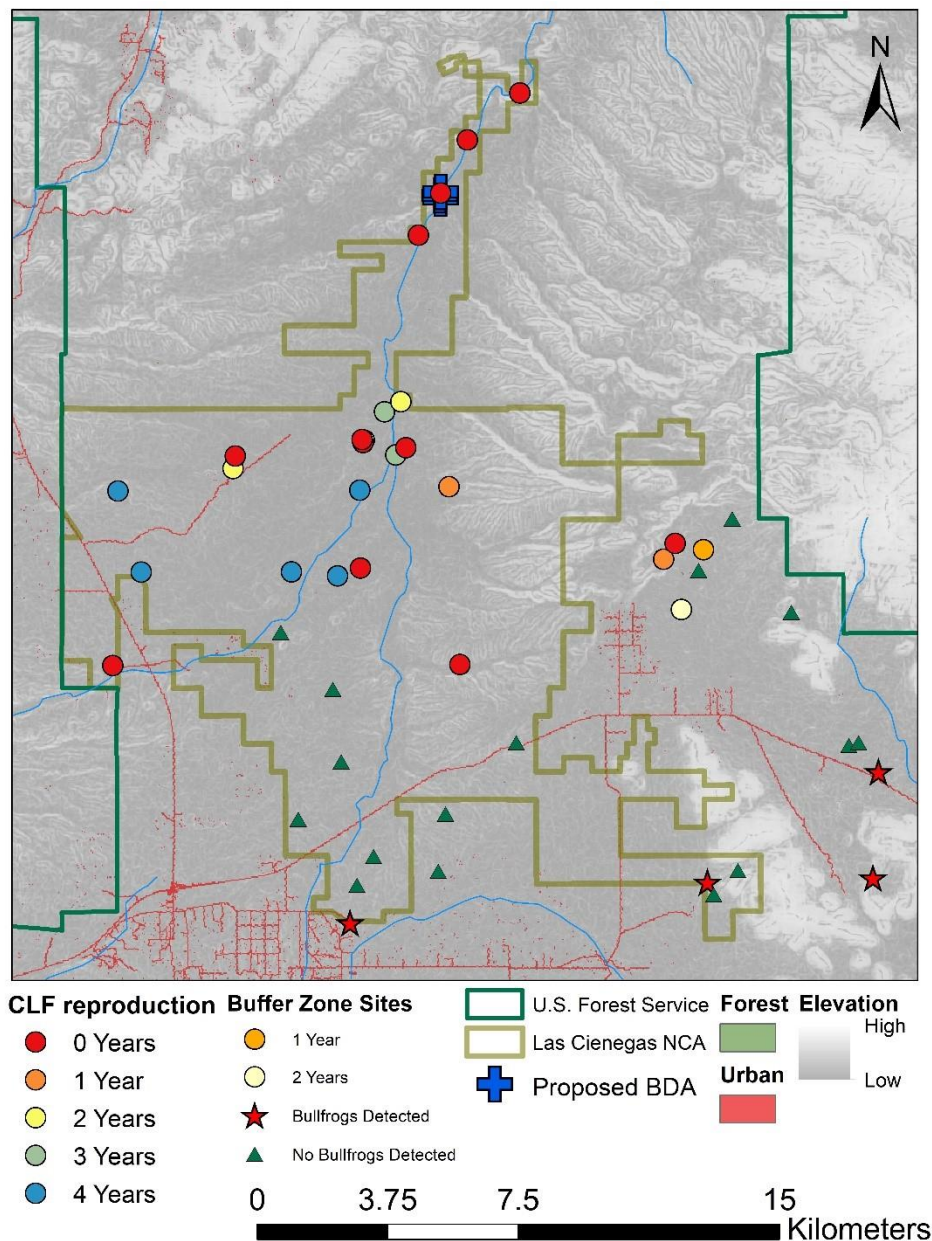


Figure 4. Number of years by site where Chiricahua leopard frog (CLF) reproduction was detected on the Las Ciénegas National Conservation Area (LCNCA) during 2021 through 2024.

We excluded 2021 results because only one month of surveys were conducted in 2021 during the report period (September 2021). CLF reproduction was suspected to have occurred at Bill's W.P. during 2024 (but not confirmed) and is shown on this map as reproduction having occurred during four years. Elgin Buffer Zone sites where CLF reproduction was detected (Hospital Tank and State Tank) are also denoted as are Buffer Zone sites where bullfrogs were removed. Proposed BDA are proposed locations of beaver dam analogs that are planned to be installed during December 2024.

We performed multiple translocations of CLF during this study (Table 4). Four sites on the LCNCA received a single translocation of CLF as part of this study (Gaucha W.P. [2021], Maternity Well W.P. [2021], Karen’s Tank [2022], Road Canyon W.P. [2022]). Cinco Well W.P. received two translocations, one during 2022 and the second during 2023. All translocations were of $n = 40\text{--}71$ juvenile CLF with one exception where two egg masses were translocated to Maternity Well W.P. The sources of these translocations were other sites on or near the LCNCA except for one site on the Audubon Society’s Appleton-Whittell Research Ranch approximately 9 km southeast of the LCNCA.

Table 4. Descriptions of Chiricahua leopard frog translocation events on the Las Ciénegas National Conservation Area during September 2020 through October 2024.

Date	Recipient Site	Source Site	Number/Ages Translocated	Notes
22 June 2021	Gaucha W.P.	Bill’s W.P.	43 juveniles	75 CLF larvae detected during one sein pass on 22 October 2021
14 May 2021	Maternity Well W.P.	Bald Hill W.P. ¹	2 egg masses	Larvae, juveniles, and adults observed during subsequent 2021 surveys
29 June 2022	Karen’s Tank	Cottonwood W.P.	40 juveniles	Adult CLF observed during August and October 2022
23 June 2022	Road Canyon W.P.	Bill’s W.P.	40 juveniles	Adult CLF observed during August and October 2022
23 June 2022	Cinco Well W.P.	Bill’s W.P.	40 juveniles	Adult CLF observed during August and October 2022
5 July 2023	Cinco Well W.P.	Bill’s W.P.	71 juveniles	Adult CLF observed during August and October 2023

¹Source site on Audubon Society's Appleton-Whittell Research Ranch

Elgin Buffer Zone Sites

Within our core 13 Elgin Buffer Zone monitoring sites, we conducted 112 surveys during 2021–2024. No CLF were detected at these sites. We detected bullfrogs in three of these sites: BZ 10 (2021), Jack Daniels Dam (2023), and Mustang Dam (2021 and 2022). We removed bullfrogs all sites. We removed adult female bullfrogs that were of reproductive size from BZ 10 and Jack Daniels Dam. However, neither of the sites had evidence of bullfrog reproduction (i.e., eggs or larvae). We conducted an additional 19 surveys across nine additional buffer zone sites with six of these sites only receiving a single survey due to being dry (Table 2). Bullfrogs were detected and removed at only one of these nine sites (Jim Davies Pond) during its single survey during 2021. We detected CLF at two of these nine sites. We first surveyed State Tank in 2024 and detected CLF reproduction (i.e., one juvenile detected during a pre-monsoon season survey on 13 June 2024). We surveyed Hospital Tank during 2023 and 2024 and detected CLF reproduction during both years. Specifically, during 2023 we detected 60 and 85 larvae during April and May, respectively, and approximately 400 CLF juveniles on 5 July 2023. During our 2024 surveys at Hospital Tank, we did not detect larvae, but we did observe five juvenile CLF during a pre-monsoon summer survey on 13 June and a single adult CLF on 19 September.

Other Native Herpetofauna

We report on observations of other herpetofauna of interest. Lowland leopard frogs (LLF) were detected at seven sites on the LCNCA during our study. During our four complete survey seasons, we detected LLF during all four years at two sites (Coldspring and Pump Canyon). We detected LLF at one site during three of these four years (Headwaters, 2022, 2023, 2024), at one site during two of these four years (Lower Empire Gulch, 2023, 2024), and at three

sites during one of these four years (Heart Wetlands [2023], Mattie Canyon [2023], and the Narrows [2024]). We detected LLF and CLF at five sites (Coldspring [2020-2024], Headwaters [2022, 2023, 2024], Heart Wetlands [2023], Lower Empire Gulch [2023, 2024], and Pump Canyon [2022, 2023]). We detected northern Mexican gartersnakes on three occasions at three different sites. The first was on 19 September 2020 at Cottonwood W.P., the second was on 20 July 2023 at Empire Well W.P., and the third was on 7 August 2024 at Coldspring.

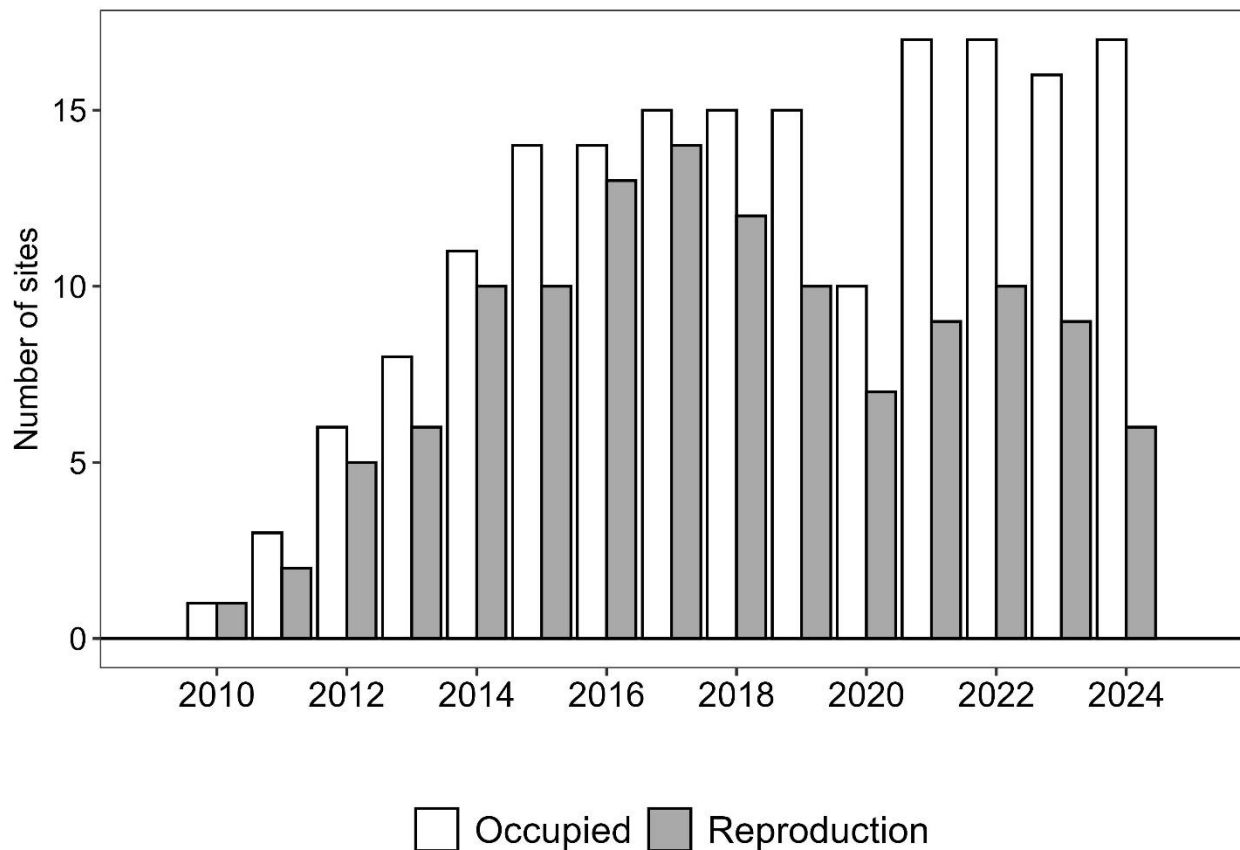


Figure 5. Number of sites on the Las Ciénegas National Conservation Area where Chiricahua leopard frogs (CLF) were detected during 2010 through 2024.

Occupied refers to sites where CLF were detected at any life stage and reproduction refers to sites where CLF reproduction was detected. Site numbers for years 2010 through 2020 denote numbers of sites occupied or with CLF reproduction as detected during August of the previous year through July of the current year (e.g., August 2019 through July 2020). Numbers for 2021 through 2024 represent results by calendar year.

Discussion

Our results from 2021–2024 confirm that the LCNCA still supports an apparently robust CLF metapopulation (Figure 5) that remains free of invasive bullfrogs since CLF restoration efforts began in 2010. Nevertheless, we encourage continued surveillance of all buffer zone sites to ensure that any bullfrogs attempting to disperse into the LCNCA are quickly removed. During each year of our study, we confirmed CLF reproduction at multiple sites, many of which appear to consistently support CLF reproduction in multiple years. The number of sites occupied by CLF and where CLF reproduction was detected remained relatively constant during 2021–2023 and is indicative of a CLF metapopulation that has expanded since restoration efforts began on the LCNCA in 2010 (Figure 4). The number of sites occupied and with CLF reproduction declined during 2019 (August 2018-July 2019) and 2020 (August 2019-July 2020) which likely reflect severe drought conditions during 2019 and 2020. However, the 2021 monsoon season was one of the wettest monsoon seasons on record and monsoon precipitation during 2022 continued well into September. These good monsoon seasons likely facilitated CLF dispersal and may have contributed to an increase in the number of occupied sites. The 2023 monsoon season was a relatively dry monsoon which may have contributed to the modest decline in number of sites with CLF reproduction seen during 2023 and 2024. The potential impacts on monsoon season precipitation on CLF dispersal and reproduction on the LCNCA highlight the importance of additional research documenting the relationship between site colonization rates and annual precipitation patterns.

Four of our 19 core monitoring sites on the LCNCA supported CLF reproduction during all four of the complete survey years included in this report period (2021-2024): Empire Well W.P., Gaucho W.P., Cottonwood W.P., and Maternity Well W.P. A fifth site, Bill's W.P., likely

supported CLF reproduction during all four years although reproduction during 2024 was not directly confirmed. Bill's W.P. received repairs to its water delivery system in 2018 and received translocated CLF larvae in 2019. Since 2019, Bill's W.P. consistently supported CLF reproduction. Gaucho W.P. and Maternity Well W.P. also received translocations during this reporting period. No CLF reproduction was observed at Gaucho Well W.P. during 2019 and 2020 (D. Hall, unpublished data) so juvenile CLF were translocated to this site during 2021 and Gaucho W.P. continued to support reproduction during 2022 and 2023. Maternity Well W.P. was created during 2012 and colonized by CLF from an unknown source (D. Hall, unpublished data). However, excessive growth by emergent vegetation resulted in an absence of standing water and no CLF had been detected since 2014. Maternity W.P. was newly renovated during 2020 and received translocated egg masses in June 2021. Our observations during 2022 and 2023 indicate that CLF have resumed breeding at this pond.

Translocations to Cinco Wildlife Pond during 2022 did not result in reproduction during 2023 nor did translocations to Road Canyon Wildlife Pond during 2022. These observations highlight the value of continuing translocation efforts within the LCNCA and in subsequent research to better understand factors influencing the success of CLF translocations on the LCNCA. Our observations of questionable but possible breeding activity at some sites during 2023 highlight the value of repeated site visits throughout the field season to better document the presence of reproduction in the face of imperfect detection of CLF eggs and larvae.

We make a note of potential trends in CLF observations within our lotic sites along Cienega Creek that point to metapopulation dynamics. CLF reproduction was detected during 2021 (one larvae netted on 7 September 2021) and 2022 (two egg masses observed on 21 April 2022) and as many as 29 adult CLF (7 September 2021) and 53 adult CLF (19 October 2022)

were observed in a single survey. During 2023 and 2024 no more than two adult CLF were detected on a single survey (2 November 2023 and 11 September 2023) and no juveniles or larvae were detected during these years. The causes of these declines are unknown but one hypothesis is increased sedimentation from heavy 2017 and 2021 monsoon rains causing slot pools to fill up, reducing water depth and therefore the amount of aquatic habitat for early life stages. In contrast, we detected CLF reproduction at Lower Empire Gulch during 2022, 2023, and 2024. We also detected lowland leopard frogs at Lower Empire Gulch during 2023 and 2024 but not during 2021 and 2022. We detected CLF during every year of this reporting period in the Coldspring reach of Cienega Creek although we never detected CLF reproduction. In contrast, we detected evidence of lowland leopard frog reproduction in Coldspring during 2022 (a juvenile observed on 15 June 2022) and 2024 (16 juveniles observed 20 June 2024). We only detected CLF at Pump Canyon during 2021 (8 October 2021) and 2024 (29 August 2024) although no evidence of CLF reproduction was detected. In contrast, we observed relatively large numbers of lowland leopard frogs (66 adults on 19 October 2022, 23 adults on 11 October 2023, and 45 adults on 24 October 2024) at Pump Canyon. We also observed lowland leopard frogs at the Narrows during two surveys in July 2024 although no CLF were detected. A single survey to Mattie Canyon on 11 May 2023 detected lowland leopard frogs but no CLF. Our observations on the distribution of CLF and lowland leopard frogs are consistent with previous observations indicating that CLF become less abundant on Cienega Creek as one moves downstream (i.e., northwards). Nevertheless, the presence of two closely related native leopard frog species in such close proximity provides an opportunity for further investigation into the inter-specific relationships between CLF and lowland leopard frogs.

We detected bullfrogs at only four sites within the Elgin Buffer Zone: BZ 10 (2021), Mustang Dam (2021 & 2022), Jim Davis Pond (2021), and Jack Daniel's Dam (2023). Adult bullfrogs were only detected at BZ 10, Mustang Dam (2021), and Jack Daniels Dam. All detected adults were removed from Mustang Dam and Jack Daniels Dam. All other bullfrog detections were of juveniles and no bullfrogs have been detected at sites on Elgin Buffer Zone since 16 August 2023.

We also note the continued presence of CLF reproduction at Hospital Tank, a site on Pima County land east of the LCNA that has served as a source site for past CLF translocations onto LCNCA sites during 2019 (Hall 2021). We surveyed Hospital Tank during 2023 and 2024 and confirmed CLF presence during 2023 and 2024. We also surveyed nearby State Tank during 2024 and confirmed CLF reproduction. Clyne Spring and Clyne Pond are two sites east of the LCNCA that have also been part of CLF restoration efforts (Rosen et al. 2013, Hall 2021). Both sites dried during the summer of 2021, but adult CLF were detected at both sites during October 2021. Since then, we have detected CLF reproduction at Clyne Pond during 2023 and even detected 110 adult CLF during a 20 July 2023 survey. CLF were detected at Clyne Pond during 2024 but without evidence of reproduction. No CLF were detected at Clyne Spring during 2022 and only a single adult CLF was detected at Clyne Spring during 2023 (16 August 2023). We suspected that CLF dispersed back into Clyne Spring and Clyne Pond from Hospital Tank although additional monitoring will be needed to confirm this hypothesis. We nevertheless encourage continued monitoring at these sites east of the LCNCA.

We noted conditions at some sites on the LCNCA at which habitat restoration activities may benefit CLF. Maternity Large fluctuations in water levels at Cinco and Bill's Wildlife Ponds occurred during 2021, 2022, and 2023. Water levels at Bill's W.P. were noticeably lower

than normal during May 2023. We observed CLF tadpoles during our March 2023 surveys at Bill's Wildlife Pond but observed lower than expected numbers of CLF juveniles in August 2023. We also noted that the frog exclusion fences previously installed around Heart, Crescent, and Egret Wetlands and Sweetwater Wetlands are now unnecessary for preventing bullfrog breeding and removal of these fences may increase the accessibility of these sites to dispersing CLF. We also noted continued vegetation encroachment by perennial Asteraceae and *Bidens* spp. at Road Canyon and Cottonwood Wildlife Ponds which could potentially reduce the amount of aquatic CLF habitat. We encourage continued monitoring of water depth and vegetation levels at CLF sites on the LCNCA to guide future decisions related to aquatic habitat restoration at these sites.

Acknowledgments

We would like to thank the many individuals that have helped make this project possible. We thank Christina Perez and the Bureau of Land Management for providing funding, site access, and logistical support for this project. We would like to thank Jace Lankow, Raul Vega, Stephanie Austin, Harley Davis, Connor McNally, Samantha Crone, Soren Steinfeldt, Kaylee Wilt, and Hannah Youngwirth for assistance in the field. This work was conducted under permits from the U.S. Fish and Wildlife Service (TE02234C and ESPER0033846), Arizona Game and Fish Department (SP410389), and the University of Arizona Institutional Animal Care and Use Committee (2022-0871). The comments of Anthony Pawlicki, Alex Koeberle, and Paul Bartelt greatly improved this report. Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Literature Cited

- Brown, D. E., editor. 1994. Biotic communities: southwestern United States and northwestern Mexico. University of Utah Press, Salt Lake City, Utah.
- Bury, R. B., and J. A. Whelan. 1985. Ecology and management of the bullfrog. U.S. Department of the Interior, Fish and Wildlife Service, 36 pp.
- Hall, D. H. 2015. 2014-2015 Frog Project accomplishments at Las Cienegas National Conservation Area, Arizona.
- _____. 2019. Local population dynamics of the Chiricahua leopard frog (*Rana chiricahuensis*), a federally listed frog, within the Las Cienegas National Conservation Area in Arizona. Final report to Cienega Watershed Project, 2014-2019.
- _____. 2021. Annual report: status of the Chiricahua leopard frog population on the Las Cienegas National Conservation Area, 2021.
- Hossack, B. R., E. B. Oja, A. K. Owens, D. Hall, C. Cobos, C. L. Crawford, C. S. Goldberg, S. Hedwall, P. E. Howell, J. A. Lemos-Espinal, S. K. MacVean, M. McCaffery, C. Mosley, E. Muths, B. H. Sigafus, M. J. Sredl, and J. C. Rorabaugh. 2023. Empirical evidence for effects of invasive American Bullfrogs on occurrence of native amphibians and emerging pathogens. *Ecological Applications* 33:e2785.
- Jarchow, C. J., B. R. Hossack, B. H. Sigafus, C. R. Schwalbe, and E. Muths. 2016. Modeling habitat connectivity to inform reintroductions: a case study with the Chiricahua leopard frog. *Journal of Herpetology* 50:63-69.
- Rosen, P. C., and C. R. Schwalbe. 1995. Bullfrogs: Introduced predators in southwestern wetlands. Pages 452-454 in T. L. Edward, S. F. Gaye, E. P. Catherine, D. D. Peter, and J. M. Michael, editors. *Our living resources: A report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems*. U. S. Department of the Interior, National Biological Service, Washington, D.C.
- Rosen, P. C., N. Steklis, D. J. Caldwell, and D. H. Hall. 2013. Restoring leopard frogs and habitat in Sky Islands grasslands (Arizona).
- Sredl, M. J., and R. D. Jennings. 2005. *Rana chiricahuensis*: (Platz and Mecham, 1979) Chiricahua leopard frog. Pages 546-549 in M. J. Lannoo, editor. *Amphibian declines: the conservation status of United States amphibians*. University of California Press, Berkley, California.
- Suhre, D. O. 2010. Dispersal and demography of the American bullfrog (*Rana catesbeiana*) in a semi-arid grassland. University of Arizona, Tucson.
- U. S. Fish and Wildlife Service. 2007. Chiricahua leopard frog (*Rana chiricahuensis*) recovery plan. U.S. Fish and Wildlife Service, Southwest Region, Albuquerque, New Mexico.