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Assessing the distribution of and threats to Species of Greatest Conservation Need frog species in eastern New Mexico

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INTRODUCTION

Amphibians are among the most sensitive indicators of ecosystem health (Alford and Richards 1999), and New Mexico's riparian and wetland habitats, particularly along the Pecos River, support a unique assemblage of species in both the High Plains and Tablelands and Chihuahuan Desert ecoregions (NMDOW 2025). Among these, the Species of Greatest Conservation Need (SGCN) Blanchard's Cricket Frog (*Acris blanchardi*; Figure 1A), Rio Grande Leopard Frog (*Lithobates berlandieri*; Figure 1B), and Plains Leopard Frog (*L. blairi*; Figure 1C) are of conservation concern in New Mexico (NMDOW 2025). Each species plays an important ecological role and is dependent on permanent or semi-permanent aquatic habitats, systems that are increasingly threatened by drought, groundwater depletion, altered hydrology, and invasive species (Walls et al. 2013; Falaschi et al. 2020).

Blanchard's Cricket Frog (Hylidae) is a small, highly aquatic treefrog that occupies shallow, vegetated margins of ponds, streams, and wetlands along the Pecos River in eastern New Mexico (Degenhardt et al. 1996), but recent records are sparse. Across much of its range in the central United States, populations of the Blanchard's Cricket Frog have experienced sharp declines (Youngquist et al., in prep), attributed to a combination of contaminants (Reeder et al. 2005), altered hydrology (Bukaita 2026), and disease (Blackburn 2001). In New Mexico, these frogs are at the extreme western edge of their distribution, where populations have likely always been patchy and vulnerable to environmental changes, which magnifies the impacts of threats to this species along the Pecos River.

Similarly, both Rio Grande Leopard Frog and Plains Leopard Frog (Ranidae) are native frogs that play key ecological roles as both predators and prey in riparian ecosystems such as the Pecos River. The Rio Grande Leopard Frog occupies primarily the southern and low-elevation portions of New Mexico along the lower Pecos River drainage and can be found in associated waters, springs, stock ponds, canals, and agricultural ditches (Degenhardt et al. 1996). It uses both permanent and temporary water bodies in grassland, shrubland, desert, and riparian zones. The Plains Leopard Frog occurs throughout the eastern plains and middle and upper parts of the Pecos River, seeming to prefer permanent water bodies, especially with vegetated margins (Degenhardt et al. 1996). Both species face pressures from habitat fragmentation, declining water availability, possible disease, and invasive predators, like many other ranids (Rorabaugh et al. 2018).

All three anuran species are listed as SGCN in the New Mexico Department of Wildlife's (NMDOW's) State Wildlife Action Plan for New Mexico (SWAP), emphasizing the urgent need for updated field data to inform management and conservation actions (NMDOW 2025). To our knowledge, there have been no comprehensive surveys for Blanchard's Cricket Frog completed in New Mexico, and most available locality records are historical or were opportunistic occurrences that resulted from efforts targeting other species. Anecdotal reports suggest that these species may have declined further in recent years, particularly in areas affected by drought, groundwater depletion, and river management practices.

However, the current status and distribution of Blanchard's Cricket Frog, Plains Leopard Frog, and Rio Grande Leopard Frog in eastern New Mexico remain poorly documented.

Compounding these challenges is the widespread presence of the American Bullfrog (*Rana* [*Aquarana*] *catesbeiana*; Figure 1D), an invasive species introduced for sport and food (Bury and Whelan 1985). Previous research along the Pecos River has identified populations of American Bullfrogs near Santa Rosa, Guadalupe County, but not in other locations downstream (Drew Davis, unpubl. data). Bullfrogs are voracious predators of native frogs and vertebrates and are strong competitors with native species (Kraus 2009). Their establishment along the Pecos River drainage poses a significant threat to native amphibian communities. Effective amphibian conservation in eastern New Mexico requires both updated knowledge of native species distributions and targeted management of invasive bullfrogs.

This project seeks to provide an updated assessment of the occurrence, population status, and habitat associations of the Blanchard's Cricket Frog, Plains Leopard Frog, and Rio Grande Leopard Frog along the Pecos River in eastern New Mexico. It also supports management actions to reduce the impact of invasive American Bullfrogs by encouraging members of the public to record observations and conducting targeted eradication efforts. These efforts target three priority Conservation Opportunity Areas (COAs) in eastern New Mexico and follow proposed and/or recommended actions as described by the 2025 SWAP (NMDOW 2025).

MATERIALS AND METHODS

Survey Sites.—We identified 20 sites along the Pecos River to conduct frog surveys. Sites were located within Chaves (n = 2), De Baca (n = 3), Eddy (n = 12), and Guadalupe (n = 3) counties (Figure 2; Table 1). The majority (n = 19) were located on public lands managed by the Bureau of Land Management, New Mexico State Land Office, NMDOW, New Mexico Energy, Minerals, and Natural Resources Department, City of Carlsbad, City of Santa Rosa, and U.S. Fish and Wildlife Service. We acquired all appropriate permits before accessing all parcels. The remaining site was located on private land, and we received written consent from the landowner before accessing their property.

Audio Surveys.—We deployed 20 Autonomous Recording Units (ARUs) (Song Meter Micro II: n = 2, Song Meter Mini II: n = 18; Wildlife Acoustics, Concord, MA), one per survey site, from 18–21 April 2026. We attached ARUs to riparian vegetation using either zip ties or paracord to avoid ground disturbance through use of a stake, and we placed the recorders in locations that minimized the risk of tampering and flood damage. Each recorder was set to begin recording daily at 1700 h, collecting a 3-min audio recording every 30 min until 0000 h. This resulted in a total of 15 recordings collected each day per ARU. ARU microphones were oriented toward the Pecos River, and we selected sheltered locations with minimal background noise when possible. ARU recordings were processed manually using Wildlife Acoustics Kaleidoscope Pro software (Wildlife Acoustics, Concord, MA). Frog species' presence was identified by visualizing their calls in a spectrogram (Figure 3), and each species detected in each recording was given a call intensity score from 0–3 following Weir and Mossman (2005; Table 2).

Visual Encounter Surveys.—We conducted distance-standardized visual encounter surveys (VESs) (Crump and Scott 1994) at each of the 20 sites between 20 May 2026 and 17 June 2026. Given the short timeline of this funding period, sites were only surveyed a single time. We initially aimed to survey 500-m transects as measured with a Garmin eTrex 10 handheld GPS unit (Garmin, Olathe, KS). Due to the extensive time commitment associated with longer transects where frogs were plentiful, we shortened the survey transect length to 250 m to improve efficiency without markedly decreasing frog species detections.

To maximize detection probability and capitalize on frog calling and activity windows, we conducted VES at night. While more logistically challenging than diurnal surveys, the high daily maximum temperatures and low humidity in eastern New Mexico make diurnal surveys less productive. Survey transects were measured and demarcated during the preceding afternoon's VES so that we could become familiar with the site and conduct efficient surveys after sunset. The number of surveyors ranged from two to six (Table 1). Surveyors thoroughly searched a 7-m-wide strip along the Pecos River ranging from 2 m into the river out to 5 m from the shoreline. While we attempted to keep survey effort equal across this area, high vegetation density, steep banks, and deep water often resulted in increased survey difficulty at locations further from the river's edge. We have rarely observed aquatic anurans at distances greater than 5 m from the water's edge. Surveyors were equipped with flashlights and dip nets (Loki Baitwell Net, Forestry Suppliers Inc., Jackson, MS) to capture encountered amphibians. Post-metamorphic amphibians were captured by hand or dip net, while tadpoles were captured exclusively using dip nets. To reduce the risk of disease transmission between captured frogs, observers wore nitrile gloves on their dominant hands. Gloves were replaced after a frog was captured. VES duration ranged from 16 to 96 min, with variability resulting from ease of travel along the transect, density of riparian vegetation, and the number of frogs observed and collected.

Upon capture, frogs were placed in a sterile plastic fish bag (ULINE S-1996, ULINE, Pleasant Prairie, WI) marked with a unique identification number. A clump of moist vegetation was placed into each bag with the frog to maintain a humid environment and reduce any risk of desiccation. Time of capture was recorded for each anuran along with any notes about their capture. A numbered flag was placed at the location where the frog was initially observed to mark the site for subsequent habitat analysis. Bagged frogs were stored in a cooler backpack until the end of the survey and were checked regularly to reduce risk of mortality (i.e., from crushing, suffocation, or overheating). Following the completion of each nocturnal survey, captured frogs were transferred into a Yeti Tundra 65 cooler (Yeti Holdings, Inc., Austin, TX). To avoid mortality from direct contact with ice, frog bags were placed on a box, bag, or other object. Frogs were typically processed the following morning and released shortly afterwards. The total time frogs were kept in coolers was <14 hr before they were released.

To reduce the risk of pathogen transmission between sites, we followed the disinfection protocol outlined in Lannoo et al. (2011). Dip nets were sterilized with a 10% bleach solution after use and were allowed to dry fully between sites. We rinsed mud and vegetation off of shoes and sterilized with a bleach solution between distant sites without direct riparian connectivity. We did not sterilize footwear between closely connected sites on the Pecos River.

Frog Processing.—Immediately upon removal from their bag, each frog was swabbed 50 times for *Batrachochytrium dendrobatidis* (*Bd*) following the methods of Lannoo et al. (2011). Sterile, rayon-tipped swabs (MWE 113; Medical Wire and Equipment, Corsham, Wiltshire, UK) were allowed to air-dry before being stored in sterile 1.5-mL microcentrifuge tubes (Jet Biofil EasyTab Microcentrifuge Tubes; Biotang, Inc., Belmont, MA) and placed on ice. Following swabbing, photographs of the dorsum, both flanks, and thigh regions of each frog were taken. While designed to facilitate confident differentiation between Plains Leopard Frogs and Rio Grande Leopard Frogs, these photographs were collected for all four focal species. During this process, frogs were regularly sprayed with Reverse Osmosis water to prevent desiccation associated with swabbing and exposure to dry air.

At most sites, a single individual of each captured SGCN was selected as a voucher specimen. In the rare cases when a frog died during overnight storage, the deceased animal was used as the voucher specimen for the site. After the *Bd* swab and photographs were collected, voucher frogs were euthanized with topical 20% benzocaine gel in compliance with standard, accepted practices and our Institutional Animal Care and Use Committee protocol (#2026-004-ARCOLL). We then recorded the mass, snout–vent length, and sex of the animal. A liver sample was collected from the animal and stored in RNAlater (tissue preservation buffer) for future ranavirus surveillance and/or genetic analyses. Finally, the specimen was injected with a solution of 10% buffered formalin, arranged for preservation, and placed within a formalin-saturated container for fixing. The physical specimens were allowed to sit in fixative for up to a week and then were transferred to a rinse water step (48 h), before ultimately being stored in 70% ethanol. All specimens are currently housed at Eastern New Mexico University. Tissue samples (i.e., livers) were stored at room temperature to facilitate optimal RNAlater activity following collection (24–48 h), then transferred to a -80°C freezer upon returning to the lab.

Following photography, we collected toe clips from non-vouchered frogs. The distal phalanges of the third toe on the rear left foot were removed using sterile instruments and stored in RNAlater for future ranavirus surveillance and/or genetic analyses. Following collection of the toe clip, the frog was returned to its numbered bag and returned to the cooler until all frogs were processed. The processed frogs were then transported to their capture location and released.

Fresh nitrile gloves were worn while processing each frog to reduce the risk of disease transmission and false positives in subsequent pathogen analyses. All frog processing tools (e.g., forceps, scissors) were disinfected using a 10% bleach solution between individuals.

Site Assessment.—Before and immediately after conducting a VES at a site, we measured and recorded maximum wind speed (km/h), relative humidity, and air temperature (℃) using a handheld weather meter (Kestrel 3500; Kestrel Instruments, Boothwyn, PA). During visits to each site, we described the type and severity of human disturbance. The use of a human disturbance severity score (Table 3) facilitated consistent assessment of anthropogenic landscape alteration across all survey sites. Similarly, the use of a salt cedar (*Tamarix* spp.) score (Table 4) facilitated consistent evaluation of invasive Salt Cedar presence and dominance at each survey site. The three most dominant of six vegetation types (herbaceous, emergent, floating, submerged, woody, woody debris) were also recorded at each site (Table 5). Gauge height from the nearest river gauge at the time of the survey was sourced from the U.S. Geological Survey (USGS) National Water Dashboard (USGS 2026). The fraction of the moon that was visible during the survey was sourced from the U.S. Navy Astronomical Applications Department (USNAAD 2026).

Microhabitat Assessment.—We selected nine random background microhabitat plots before arriving at each site. Each plot was spaced randomly along the transect using a number generator from 1 to 250. Plots within 5 meters of a pre-existing plot were discarded and replaced with another plot. After determining distance along the transect, we used random number generation to determine the distance of each plot from (or into) the Pecos River. The bank was subdivided into three zones: aquatic (from the water's edge to 2.0 m into the water; values 0.0–2.0), bank (from the water's edge to 2.0 m up the bank; values 3.0–5.0), and riparian (from 2.1–5.0 m away from the edge; values 5.0–7.0). Each plot was assigned to one of these categories so that there were three plots within each category for each site. Exact distance from the water was then randomized using a random number generator with a resolution of 10 cm.

During surveys, we used the trip computer function on a Garmin eTrex 10 handheld GPS unit to determine distance along the transect and locate the randomly selected distance for each random microhabitat plot. The afternoon/evening preceding each survey, we laid out the transect, placing flags at the location of the nine background plots. Later, during the survey, we recorded the ground (bank or riparian plots) or water (aquatic plots) temperature at each background plot. Water temperature was measured with a Hach Pocket Pro pH meter (Hach Co., Loveland, CO), while surface temperature was measured with an Etekcity Lasergrip 774 handheld infrared thermometer (Etekcity, Anaheim, CA). For aquatic plots that were inaccessible due to deep water or high flow, we attempted to measure microhabitat attributes as close to the predetermined point as possible. Whenever a frog was captured or identified, a plot was created at the location where it was first observed. Ground or water temperature was recorded at the time of capture depending on the plot type (aquatic vs. bank vs. riparian).

The morning after each survey and following frog release, we recorded a suite of microhabitat features for each background and frog microhabitat plot (Table 6). One-meter diameter plots were laid out with a standard meter stick. Substrate type was assessed based on assessment of texture, and substrate moisture was determined by feel (USDA 1998). Low cover was defined as coarse objects that could protect a frog that were under 2 m in height. Percentage of low cover was determined for each quadrant of the 1-m plot at a 5% resolution, and all low cover types present within the plot were recorded. Percentage of overstory cover was determined with a spherical densiometer (Forest Densiometers, Bartlesville, OK), and all overstory cover types present within the densiometer field were recorded. Slope was measured with a handheld clinometer in direct contact with the substrate (Eyeskey CM-360-%-A; Eyeskey Optics, Hong Kong). For aquatic plots, water depth was measured with a standard meter stick. When depth exceeded 1-m, exact depth was not measured and “>1 m” was recorded instead. Water pH was measured with a Hach Pocket Pro pH meter, and water conductivity was measured with a YSI ProQuatro Multiparameter Meter (YSI, Yellow Springs, OH).

Citizen Science Engagement.—We built an iNaturalist project, *Frogs of Eastern New Mexico* (https://www.inaturalist.org/projects/frogs-of-eastern-new-mexico), to compile and encourage public reporting of invasive American Bullfrogs and SGCN across eastern New Mexico. The project automatically collects all frog observations submitted to iNaturalist from Chaves, Colfax, Curry, De Baca, Eddy, Guadalupe, Harding, Lea, Mora, Quay, Roosevelt, San Miguel, and Union counties. Additionally, to encourage reporting from people who may not be actively using iNaturalist, we created a poster that links to the project, shared it with partner agencies, and posted it at parks, museums, and natural areas throughout the Pecos River region.

Species Occurrence Records.—Prior to field sampling, we compiled occurrence records for all four focal species within New Mexico: Blanchard’s Cricket Frog, Plains Leopard Frog, Rio Grande Leopard Frog, and American Bullfrog. Observations were sourced from ARCTOS (https://arctos.database.museum), VertNet (https://www.vertnet.org), HerpMapper (https://herpmapper.org), and iNaturalist (https://inaturalist.org). Additionally, individual collections with data not publicly accessible were queried, such as historic collections at Eastern New Mexico University and New Mexico State University. All iNaturalist records were vetted for identification accuracy prior to inclusion. Additionally, iNaturalist occurrence records that were obscured (precise coordinates were not visible) were either excluded or the observers were contacted and precise coordinates were requested. Only limited identifications of occurrence records based on voucher specimens were conducted due to time constraints, but additional verification, especially of occurrence records that fall outside of any species’ expected range, will occur in the future.

American Bullfrog Removal.—Any American Bullfrogs collected during surveys were euthanized and preserved (as previously described). Additionally, at sites where American Bullfrogs were known to be present, we attempted to collect as many individuals as possible for euthanasia (not part of formal frog VESs) using hand and dip net capture, as well as baited (dry cat food) minnow traps (#TRP-M-BK, 16.5 × 9 in; Bass Pro Shops, Springfield, MO). American Bullfrog removal was not restricted to the 20 formal survey sites. Despite the lack of a direct, permanent connection to the Pecos River, the J. Kenneth Smith Bird Sanctuary in Roswell, New Mexico, was added as a bullfrog control location due to multiple independent iNaturalist reports of recent American Bullfrog sightings. Additionally, prior to fixing American Bullfrog specimens, we excised the entire gastrointestinal tract of each individual and preserved it in 95% ethanol within a glass jar for future microplastics and diet research.

Statistical Analyses.—Cumulative link mixed models (CLMMs) or generalized linear mixed effects models (GLMMs) were used to evaluate the relationship between river gauge height and call intensity. Gauge data were sourced from the USGS National Water Dashboard, and site and recording time were included as random effects. For each site, the closest gauge station on the Pecos River main stem was selected. If the closest gauge station was separated from the site by an impoundment, data from the closest station without an intervening barrier were used. For all four species and both model types, a second model containing the same variables but excluding gauge data was fitted. Aikaike Information Criterion (AIC) values were used to compare model performance between the models containing and excluding river gauge height as a predictor.

Fisher's exact tests were used to compare the associations between categorical microhabitat and site-level features and frog presence/absence. While Chi-squared tests were originally planned, the low expected counts resulting from low sample sizes decreased the accuracy of these tests beyond acceptable limits. Mann-Whitney U tests were used to assess associations between quantitative variables and frog presence/absence. When significant associations were detected, medians and bar plots were implemented to determine the direction of each association. A significance threshold of $\alpha = 0.05$ was used for all analyses. All statistics were completed in Program R/Rstudio (Posit Inc., Boston, MA).

RESULTS

Frog Detections.—Focal frogs were located by VES or ARUs at 16 of 20 sites. A total of 40 frogs were captured and processed (Blanchard's Cricket Frog: n = 25; Plains Leopard Frog: n = 2; Rio Grande Leopard Frog: n = 1; American Bullfrog: n = 12). Five additional frogs were identified but not captured and were included for microhabitat analysis only (Blanchard's Cricket Frog: n = 3; Rio Grande Leopard Frog: n = 2). Two Plains Leopard Frogs, one at the Roberston State Land Office Lease and another at Sumner Lake State Park, were observed but not captured prior to our implementation of non-capture microhabitat plots. As such, these frog observations did not contribute to microhabitat analysis.

In total, 18,678 call recording spectrograms were assessed visually, with 2632 recordings (14.3%) capturing calling anurans. The Blanchard's Cricket Frog was detected by VES at seven sites (Avalon Dam, Bataan Park, Brushy Draw, Diving Rock, Longhorn Road Crossing, Pierce Canyon Crossing, and Six Mile Dam) and by ARUs at two additional sites (Harroun Crossing and W.S. Huey Wildlife Management Area). Of note, there were two sites where the Blanchard's Cricket Frog was detected by VES, but not by ARUs (Bataan Park and Six Mile Dam; Figure 4). The Plains Leopard Frog was detected by VES at five sites (City of Santa Rosa Water Treatment Facility, Diving Rock, Lake Sumner State Park, NMSLO Lease, Private Land) and was detected at two additional sites (Bosque Redondo Lake Park and Brantley Outflow) by audio surveys. Additionally, there were three sites where the Plains Leopard Frog was detected by VES, but not by ARUs (Diving Rock, Lake Sumner State Park, and NMSLO Lease; Figure 4). The Rio Grande Leopard Frog was detected by VES at Brushy Draw alone, though calling individuals were heard through audio surveys at Harroun Crossing (Figure 4). Despite three post-metamorphic frog sightings at Brushy Draw, no call activity was recorded via ARUs. American Bullfrog was detected by both VES and audio survey at two sites (City of Santa Rosa Water Treatment Facility and Private Land; Figure 4).

Frog Processing.—Basic morphometric data (sex, snout–vent length, mass) were recorded for each captured individual and are summarized in Table 7. In total, 11 (of 25) Blanchard's Cricket Frogs, the single Rio Grande Leopard Frog, 2 Plains Leopard Frogs, and all 12 American Bullfrogs were preserved as voucher specimens, with no more than one post-metamorphic individual retained from each site for SGCN. Non-lethal toe clips were collected from the remaining 14 Blanchard's Cricket Frogs and one Plains Leopard Frog. Skin swabs and identification photographs were collected from every captured individual.

Site-level Habitat Selection.—Due to low expected Chi-square counts, Fisher's exact tests were used to evaluate the statistical significance of associations between frog presence/absence and six categorical variables for all four focal species (Table 8). Primary, secondary, and tertiary site-level vegetation ranks were not significantly associated with frog presence for any species at any study site. Likewise, Off-Highway Vehicle (OHV) use and livestock evidence were not significantly associated with any frog presence metric. The presence or absence of invasive American Bullfrogs was not significantly associated with native frog presence or absence at any of the study sites.

Mann-Whitney U tests were used to evaluate the associations between frog presence/absence and nine quantitative variables (Tables 9–12). No statistically significant associations were detected for any of these variables for any of the four focal species. A near-significant association ($p = 0.06$) between American Bullfrog presence/absence and anthropogenic disturbance severity score was detected. The median score for sites without American Bullfrog present was 3, while the median for sites with American Bullfrog present was 1.

Microhabitat Assessment.—Microhabitat variables were measured for a total of 224 plots; of these, 180 plots were randomized background plots, 28 were Blanchard's Cricket Frog plots, 11 were American Bullfrog plots, 3 were Rio Grande Leopard Frog plots, and 2 were Plains Leopard Frog plots. One bullfrog tadpole sighting on the Private Land parcel in Santa Rosa was excluded from microhabitat analysis due to methodological modifications made early in the survey period. With the exception of distance from water and plot type preference, microhabitat analysis was conducted within plot types (aquatic, bank, riparian). No frogs were observed within the riparian plot type throughout the survey, so it was excluded from analysis. Due to the very small sample sizes for Plains Leopard Frogs and Rio Grande Leopard Frogs, microhabitat evaluation does not provide reliable or biologically relevant results. As such, only Blanchard's Cricket Frog and American Bullfrog plots were evaluated.

As with site-level analysis, Fisher's exact tests were used to evaluate the association between categorical microhabitat variables and the presence/absence of a frog species (Table 13). The Blanchard's Cricket Frog showed a strong preference for aquatic and bank plot types, indicating strong affinity for habitat in and adjacent to the water ($p = 0.0092$; Figure 5). This species was also associated with the presence of emergent vegetation within both aquatic and bank survey plots (aquatic: $p = 0.0080$; bank: $p = 0.0080$; Figure 6). Associations within aquatic plots between substrate type, herbaceous cover, woody cover, undercut banks, rocky cover, and aquatic vegetation and the presence/absence of the

Blanchard's Cricket Frog were not statistically significant in this analysis. Similarly, bank plot associations between substrate type, substrate moisture, woody cover, herbaceous cover, rocky cover, and aquatic vegetation and the presence of the Blanchard's Cricket Frog were not statistically significant (Table 14). The American Bullfrog showed a similar pattern of plot type preference to the Blanchard's Cricket Frog in terms of association with only aquatic and bank plot types, though the effect was not statistically significant ($p = 0.11$). None of the other variables measured for bank and aquatic plots were significantly associated with the presence of the American Bullfrog (Table 14).

Mann-Whitney U tests were used to evaluate associations between quantitative microhabitat variables and the presence/absence of a frog species. Distance from water differed significantly between frog and background plots for Blanchard's Cricket Frog ($W = 985$, $p = 0.0006$, median absent = 1 m, median present = 0 m) and American Bullfrog ($W = 141$, $p = 0.0006$, median absent = 1 m, median present = 0 m). Blanchard's Cricket Frog presence was significantly associated with slower flow ($p = 0.012$), warmer water temperature ($p = 0.011$), and shallower water ($p = 0.038$; Table 15) in aquatic plots. American Bullfrog presence was not significantly associated with any of the quantitative microhabitat variables in aquatic plots (Table 17). In bank plots, the presence of Blanchard's Cricket Frog was not significantly associated with any quantitative microhabitat variables (Table 16). Though not associated with any quantitative variables in aquatic plots, presence of American Bullfrog was associated with moderate percentages of low cover in bank plots ($p = 0.038$; Tables 17-18).

Call Intensity and Gauge Assessment.—The CLMM for the Blanchard's Cricket Frog call score vs. river gauge height produced an AIC value of 5651.26, while the model excluding gauge height as a predictor produced an AIC value of 5650.24 (Table 19). The low ΔAIC of 1.02 indicates no evidence for an association between these variables. The river gauge-containing model for the Plains Leopard Frog produced an AIC of 1123.51, and the river gauge-excluding model an AIC of 1128.68. The ΔAIC of 5.17 and river gauge height model coefficient of -0.0015867 indicate that there is moderate evidence for a negative association between the Plains Leopard Frog call score and river gauge height. The CLMM for American Bullfrog call score and gauge height produced an AIC of 1599.49. The gauge-excluding model produced an AIC value of 1598.21. The low ΔAIC of 1.28 provides no evidence for an association between these variables.

Because of the low number of recordings for the Rio Grande Leopard Frog, there was insufficient information for a CLMM to converge. As such, a GLMM was used with a simplified binary variable for amphibian calling occurrence. The GLMM for the Rio Grande Leopard Frog call presence vs. river gauge height produced an AIC value of 437.0, while the model without the river gauge height had an AIC of 439.9 (Table 19). The resulting ΔAIC of 2.9 indicates weak evidence for a positive association (coefficient: 0.41536) between Rio Grande Leopard Frog call activity and river gauge height.

Citizen Science Engagement.—The *Frogs of Eastern New Mexico* iNaturalist project gathered 2,300 observations of anurans in the eastern counties of New Mexico. In total, 18 species were identified by 577 observers, and 83 observations of the American Bullfrog were gathered, 18 of which were submitted between January and July 2026 (Figure 7). While most of these American Bullfrog observations were located in the Canadian, Mora, and upper Pecos drainages, three 2026 observations were submitted from the ponds at the J. Kenneth Smith Bird Sanctuary in Roswell, Chaves County. Due to the apparent absence of the American Bullfrog in the Pecos River in the Roswell area and the isolated nature of the ponds, this site was selected for directed bullfrog removal efforts (described below). 164 observations were submitted for the three SGCN, with five Plains Leopard Frog sightings submitted between January and June 2026. Outside of this study, Rio Grande Leopard Frog and the Blanchard's Cricket Frog have not been reported on iNaturalist since 2025 in eastern New Mexico.

Species Occurrence Records.—A combined 5,015 occurrence records were compiled for all four focal species across New Mexico (Figure 8). 403 records of the Blanchard's Cricket Frog in New Mexico, sourced from 14 museum collections and iNaturalist, ranged from 1 April 1916 to 18 July 2025. 457 Rio Grande Leopard Frog records were combined from 16 museums, iNaturalist, and HerpMapper. The earliest record dates back to 25 July 1930, while the most recent was on 3 October 2025. 698 records of the Plains Leopard Frog, ranging from 4 October 1902 to 28 June 2026, were sourced from 12 museum collections, iNaturalist, and HerpMapper. While confirming species identifications, we discovered a historic occurrence record of a Plains Leopard Frog from Socorro County (Museum of Southwestern Biology, University of New Mexico [MSB:Herp] 34657). Socorro County has not been formally reported as a county where Plains Leopard Frogs are known to occur (Degenhardt et al. 1996; Painter et al. 2017), and a short note documenting this has been submitted (DeWeerd and Davis, submitted). 3,455 records of the American Bullfrog were sourced from 18 museums and iNaturalist. The earliest bullfrog record dated to 11 August 1934, and the most recent report was on 28 June 2026.

American Bullfrog Removal.—We detected the American Bullfrog at two (of 20) survey sites (described above), and captured individuals were euthanized and preserved. Using reports from the iNaturalist project, we identified a new site within our study area where the American Bullfrog was previously not known to occur, the J. Kenneth Smith Bird Sanctuary in Roswell, Chaves County. At the time of this report, we have conducted a single night of American Bullfrog control within this sanctuary.

On 18 June 2026, we conducted a targeted American Bullfrog removal effort at the J. Kenneth Smith Bird Sanctuary. Removal efforts included attempts at trapping tadpoles using five baited traps (roughly 5-hr deployment) and dip net capture. The use of minnow traps failed to capture any American Bullfrog tadpoles but captured large numbers of fish (primarily bullhead [*Ameiurus* sp.] and sunfish [*Lepomis* sp.]). A group of six individuals captured 92 American Bullfrogs, including both pre- (n = 15) and post-metamorphic (n = 77) individuals using dip nets over a 2-hr period (2030–2230 h) at this site. Of the 77 post-metamorphic individuals, 31 were juveniles, 28 were adult females, and 18 were adult males. All frogs were swabbed for *Bd*, tissued (liver sample) for ranavirus testing, and had their gastrointestinal tracts removed. During preservation, we found that one adult female American Bullfrog (Drew R. Davis [DRD] Field Series 13930) had consumed an adult Great

Plains Groundsnake (*Sonora episcopa*), a native species of snake that does not appear to have been previously reported in the diet of American Bullfrogs (Haag et al., submitted).

DISCUSSION

Occurrence Records.—The location of frogs captured during VES and through the use of ARUs were generally consistent with county record data from both BISON-M (https://bison-m.org/), Degenhardt et al. (1996), and Painter et al. (2017). The single exception was for the Blanchard's Cricket Frog occurrence in De Baca County, where we detected no calls or individuals during our study. The most recent detection of Blanchard's Cricket Frog in De Baca County was from a specimen collected in 2024 (DRD 11767), and we surveyed that same site (Billy the Kid Drive). While missing a species detection through a single VES is not unexpected, it is surprising that the ARU did not pick up any calling activity.

Comparative Effectiveness of Survey Methods.—At least one frog of the four focal species was detected at 16 of 20 sites surveyed. At four sites, frogs were detected during nocturnal VESs but not by the ARU. At another five sites, frogs were detected by ARUs but not by VES. At the remaining seven sites, frogs were detected by both methods. This pattern suggests that neither technique alone is sufficient for frog detection along the Pecos River.

While VESs are spatially flexible and can be altered to include likely habitat or calling frogs, they are temporally limited. Each VES was conducted within a 2-hr period on a single night between 28 May 2026 and 17 June 2026. The conditions present at each site and the activity of the frogs within that specific survey period strongly influence the success or failure of detection. While repeated sampling reduces the risk of false negatives, there was not enough time to resample any sites during this project; we anticipate repeating surveys again in 2026 and Summer 2027 using other funds. While less subject to temporal variation, ARU surveys are strongly influenced by recorder placement relative to calling habitat. While we attempted to place ARUs close to high-quality frog habitat, in many cases adequate mounting vegetation was not available in those areas and the units were placed in suboptimal habitat. In other situations, the best frog habitat (slow and shallow with edge vegetation) was located in high-traffic areas where an ARU unit might be moved, damaged, or stolen. Given the high price (approximately $150 per Song Meter Micro 2, approximately $600 per Song Meter Mini 2) of the recording units, we often prioritized security over optimal calling location at a given site.

Site-level Habitat Selection.—Neither OHV use nor livestock activity (grazing, tracks, bank erosion, feces) were significantly associated with frog presence or absence for any of the four focal species. Though we thought that intensive OHV use and livestock grazing activity at sites like Brantley Outflow, Diving Rock, and the NMSLO lease would decrease the likelihood of detection, frogs were found at all three sites. While this suggests the absence of any effect, the small sample size of sites with OHV use (n = 3) and livestock sign (n = 5) greatly reduces the potency of the associated statistical tests.

Primary, secondary, and tertiary site-level vegetation ranks were not significantly associated with frog presence. While this may indicate that plant community composition at the site level is unimportant for frog presence or absence, this pattern may also result from too simplistic a ranking system. At many sites, frogs were found in isolated pockets of suitable still-water habitat within a matrix of another apparently unsuitable habitat types. The dominant vegetation type is likely not indicative of the presence of suitable habitat at many sites. While the relative abundance of suitable and unsuitable habitat may impact the frog population size at a site, it may not have a strong impact on species presence or absence. Additionally, the relatively small sample size of sites (n = 20) could prevent detection of more subtle effects associated with dominant vegetation class.

The presence of the American Bullfrog at a site was not associated with presence or absence for any of the SGCN frogs. However, this lack of an association does not justify any conclusions about interspecific interactions between native species and the American Bullfrog. Bullfrogs were only encountered at two sites, both located in Santa Rosa. The absence of Rio Grande Leopard Frog and Blanchard's Cricket Frog from those sites is likely due to limits on their geographic range rather than interspecific interactions with the invasive frog. We cannot draw conclusions about competitive exclusion or predation pressure from our current field data and likely won't be able to in future unless American Bullfrogs invade further south into the native range of these species within the Pecos River. The Plains Leopard Frog did coexist with the American Bullfrog at both of the sites where the American Bullfrog was detected. While the apparent overlap of the American Bullfrog and Plains Leopard Frog suggests that they are able to coexist, further study at finer spatial and behavioral scales is needed to determine how American Bullfrog invasion impacts populations of native Plains Leopard Frog.

None of the quantitative site-level habitat variables were significant for any species. This is likely due to small sample sizes rather than the absence of any effect, and re-evaluation of these variables after additional sampling in July and August 2026, using other funds, will be necessary to evaluate associations. While there was a near-significant association (p = 0.060) between American Bullfrog presence and lower values of the Human Disturbance Severity Score, reliable conclusions cannot be drawn from this result. Bullfrogs were only found at two sites at the northern end of the study area, so extrapolating this relationship is not reasonable. Additional research involving bullfrog-inhabited sites across their range is necessary to evaluate this potential association.

Microhabitat Selection.—Due to the small number of Plains Leopard Frog (n = 2) and Rio Grande Leopard Frog (n = 3) plots along the Pecos River, we could not conduct microhabitat analyses for these species. While the sample sizes for the Blanchard's Cricket Frog (n = 28) and American Bullfrog (n = 11) plots were large enough to run Fisher's Exact and Mann-Whitney U tests, all results communicated herein are preliminary and will benefit from the additional rounds of sampling planned at these sites in Summer 2026 and Summer 2027, using other funds.

The Blanchard's Cricket Frog showed strong preference for bank and aquatic plots, and distance to the water was significantly lower for frog plots than for background plots. This indicates that this species has a high affinity for aquatic and river-edge microhabitats. Remaining moist in eastern New Mexico's hot and arid climate is of critical importance for this frog and remaining in or near water bodies likely prevents desiccation. Additionally, sampling was conducted during the Blanchard's Cricket Frog's breeding season, when males call from the water or bank. No frogs of this species were detected within riparian plots (from 2–5 m from the water's edge). While this is consistent with strong preference for microhabitats proximate to water, this effect may be inflated by the relative ineffectiveness of sampling within riparian plots. The area from 2–5 m from the water's edge tended to contain dense vegetation or steep banks that made sampling difficult. Despite this difficulty, we attempted to sample this area as thoroughly as possible, and the absence of even a single detected frog suggests a strong preference against riparian plots.

Blanchard's Cricket Frog presence was significantly associated with lower flow speeds, shallower depths, warmer water temperatures, and the presence of emergent vegetation within aquatic microhabitat plots. Though they are capable swimmers, Blanchard's Cricket Frogs likely select unmoving water to minimize energy expenditure. Further, females seek shallow, still areas for oviposition, and higher flow rates are not conducive to egg survival. Shallower depths limit the prevalence of fish predators that might consume adult Blanchard's Cricket Frogs or their eggs and are also linked with the slow-moving water, edge microhabitats, and emergent vegetation that were associated with Blanchard's Cricket Frog presence. While the Blanchard's Cricket Frog may be selecting warmer water for thermoregulatory purposes, warmer water is also associated with the shallower depths and stationary waters the frogs prefer. The strong association between Blanchard's Cricket Frog presence and emergent vegetation likely results from this vegetation's presence in the shallow edge habitats the frog utilizes and the cover it provides from aquatic, terrestrial, and airborne predators.

Like the Blanchard's Cricket Frog, the American Bullfrog showed a preference for bank and aquatic plots, though this association was not statistically significant ($p = 0.11$). This larger p-value is likely the result of small sample size. No American Bullfrogs were captured within riparian plots. Anticipated future sampling at the Santa Rosa sites where this species was detected for this project should provide the additional sample counts needed to clarify this relationship. Presence of the American Bullfrog was significantly associated with decreased distance from the water, further indicating that this species displays strong affinity for aquatic and river's-edge microhabitats. American Bullfrog presence was also associated with moderate percentages of low cover in bank plots. This intermediate cover density may provide the cover the frogs need to reduce predation risk, while also facilitating free movement and breeding. However, the validity of this conclusion is challenged by the small quantity of positive American Bullfrog plots used for this analysis. Additional sampling is needed to clarify this relationship.

Call Intensity and Gauge Height.—The CLMM for the relationship between call score and river gauge height provided no evidence for an association with this variable for either the Blanchard's Cricket Frog or the American Bullfrog. There was moderate evidence ($\Delta AIC = 5.2$) for a negative relationship between call score and river gauge height for the Plains Leopard Frog, so that lower river gauge heights were associated with increased call activity. The GLMM for the relationship between call presence and gauge height indicated weak evidence ($\Delta AIC = 2.9$) for an association for the Rio Grande Leopard Frog. Date and site were included as random effects in all of these models, so the effects of calling phenology and site identity have been mitigated. The apparent opposite relationship of call score to river gauge height between the two leopard frog species may be due to the much higher range of river gauge heights experienced by the Plains Leopard Frog as compared to the Rio Grande Leopard Frog. Due to block releases during the survey period, the Plains Leopard Frog was exposed to river gauge heights over 1500 cubic feet per second (cfs) while the detected Rio Grande Leopard Frog never experienced river gauge heights over 150 cfs.

Though Plains Leopard Frog call intensity was negatively associated with river gauge height, in several instances frogs were observed calling even during very high flow regimes (over 1500 cfs). It is likely that if slow-moving, shallow water is present in some areas during block releases, these frogs will continue to call. Though the relationship between call intensity and river gauge height was not significant for the American Bullfrog, like the Plains Leopard Frog, calling individuals were still detected during the block release flow states.

Bullfrogs and Citizen Science.—Over a 2-hr period, six observers removed 92 American Bullfrogs from the ponds at the J. Kenneth Smith Bird Sanctuary in Roswell. Despite this effort, numerous remaining bullfrogs continued to call after the conclusion of the control event. Several additional control sessions will be necessary to extirpate the American Bullfrog from this site. Despite the time and resources required for control, ongoing efforts are immediately necessary. Though not directly connected with the Pecos River, flooding events like those in October 2024 could move the American Bullfrog from these ponds into the main river drainage. The American Bullfrog was not encountered in nearby river stretches, so the ponds at the bird sanctuary could act as a source for novel invasion. Control will become near impossible if this spread occurs, so taking steps to eradicate the Roswell population while it is still isolated is of primary importance, especially given the number of imperiled species present along the Pecos River in this region.

Study Limitations.—The primary limitations for this study stem from its short time frame and small sample sizes. Each site was visited only once between 28 May 2026 and 17 June 2026. As a result, the likelihood of false negative detections is high, and subsequent resampling, using other funds, is needed to improve confidence in absence records. Additional sampling will also bolster sample sizes for microhabitat analysis and improve statistical power of analyses performed for all four species. The extremely small number of captured Plains Leopard Frogs and Rio Grande Leopard Frogs was especially limiting, and no viable conclusions about site-level or microhabitat selection could be drawn from the collected data.

Further, microhabitat-use analysis was based on frog detection rather than absolute presence. Certain microhabitat classes that are more difficult to survey or that provide cover for inactive frogs were likely underrepresented in the analysis. Other studies (e.g., Hinderer et al. 2021) utilize radio telemetry and closed aquatic systems to acquire a more accurate description of true microhabitat use, but those methods were not feasible in this study.

Future Directions.—Sampling similar to that described for this project, supported with other funds, will continue throughout the remainder of Summer 2026 and will resume in Summer 2027. ARUs will remain in the field until October 2026. The additional data will facilitate more robust assessments of microhabitat use, geographic distribution, and site-level associations for focal frogs. Analysis of call data through the autumn will also reduce the likelihood of false negative detections and will provide insight into the behavior of the focal frog species into the autumn months. Data from six sites on Pecos River tributaries (two sites on Rocky Arroyo, three on the Black River, and one on the Delaware River) will provide additional data for all analyses. Each of these sites has already been visited, but data were excluded from this report due to early sampling inconsistencies and limited available time. Sampling along these tributaries should bolster counts of the Rio Grande Leopard Frog particularly and will facilitate stronger microhabitat and disease analysis for the species. We are also evaluating potential sites in the gaps between Artesia, Roswell, and Fort Sumner. While public land access is difficult, we plan to seek contacts with local landowners to evaluate options in the area. Those river stretches are quite data-deficient, and research into local frog species composition is needed.

Starting in Fall 2026, the tissue samples and *Bd* swabs from sampled anurans will be used to conduct disease surveillance for the focal frog species. qPCR analysis for ranavirus and *Bd* will clarify the prevalence and effects of these pathogens in the Pecos River region. Of special interest is the potential reservoir role of the American Bullfrog, which can carry and transmit *Bd* asymptomatically (Garner et al. 2006). American Bullfrog control efforts, both at the J. Kenneth Smith Bird Sanctuary in Roswell and at sites in Santa Rosa, will continue through the fall and into next summer.

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LITERATURE CITED

Alford RA, Richards SJ. 1999. Global amphibian declines: a problem in applied ecology. Annual Review of Ecology, Evolution, and Systematics 30:133–165.

Blackburn LM. 2001. Status of Blanchard’s cricket frog (*Acris crepitans blanchardi*) along their decline front: population parameters, malformation rates and disease. M.S. Thesis, Ball State University, Muncie, Indiana. 43 + [2] pp.

Bukaita W. 2026. Winter warming and snowpack loss synergistically drive amphibian and reptile extirpation: a deep learning attribution study of climate mechanisms. Frontiers in Amphibian and Reptile Science 4:1841535

Bury RB, Whelan JA. 1985. Ecology and management of the bullfrog. U.S. Department of the Interior, Fish and Wildlife Service, Resource Publication 155. [2] + 23 pp.

Degenhardt WG, Painter CW, Price AH. 1996. The Amphibians and Reptiles of New Mexico. University of New Mexico Press, Albuquerque, New Mexico. 431 pp.

DeWeerd BJ, Davis DR. Submitted. Geographic distribution: plains leopard frog (*Rana blairi*). Herpetological Review.

Falaschi M, Melotto A, Manenti R, Ficetola GF. 2020. Invasive species and amphibian conservation. Herpetologica 76:216–227.

Garner TWJ, Perkins MW, Govindarajulu P, Seglie D, Walker S, Cunningham AA, Fisher MC. 2006. The emerging amphibian pathogen *Batrachochytrium dendrobatidis* globally infects introduced populations of the North American bullfrog, *Rana catesbeiana*. Biology Letters 2:455–459.

Haag MM, DeWeerd BJ, Myers CJ, Davis DR. Submitted. *Rana catesbeiana* (American bullfrog). Diet. Herpetological Review.

Hinderer RK, Litt AR, McCaffery M. 2021. Habitat selection by a threatened desert amphibian. Ecology and Evolution 11:536–546.

Kraus F. 2009. Alien Reptiles and Amphibians. A Scientific Compendium and Analysis. Springer, Cham, Switzerland. xii + 563 pp.

(NMDOW) New Mexico Department of Wildlife. 2025. State Wildlife Action Plan for New Mexico. New Mexico Department of Wildlife, Santa Fe, New Mexico. xxi + 759 pp.

Painter CW, Stuart JN, Giermakowski JT, Pierce LJS. 2017. Checklist of the amphibians and reptiles of New Mexico, USA, with notes on taxonomy, status, and distribution. Western Wildlife 4:29–60.

Reeder AL, Ruiz MO, Pessier A, Brown LE, Levengood JM, Phillips CA, Wheeler MB, Warner RE, and Beasley VR. 2005. Intersexuality and the cricket frog declines: historic and geographic trends. Environmental Health Perspectives 113:261–265.

Rorabaugh JC, Hossack BR, Muths E, Sigafus BH, Lemos-Espinal JA. 2018. Status of the threatened Chiricahua leopard frog and conservation challenges in Sonora, Mexico, with notes on other ranid frogs and non-native predators. Herpetological Conservation and Biology 13:17–32.

(USDA) U.S. Department of Agriculture. 1998. Estimating soil moisture by feel and appearance. United States Department of Agriculture, Natural Resources Conservation Service, Washington, D.C. Available from: https://www.wcc.nrcs.usda.gov/ftpref/wntsc/waterMgt/irrigation/EstimatingSoilMoisture.pdf.

(USGS) U.S. Geological Survey. 2026. USGS Water Data for the Nation: U.S. Geological Survey National Water Information System database. Available from: https://www.usgs.gov/tools/national-water-information-system-nwis-mapper. Accessed 25 June 2026.

(USNAAD) U.S. Navy Astronomical Applications Department. 2026. Fraction of the Moon Illuminated. Available from: https://aa.usno.navy.mil/calculated/moon/fraction?year=2026&task=00&tz=7&tz_sign=-1&tz_label=false&submit=Get+Data. Accessed 25 June 2026.

Walls SC, Barichivich WJ, Brown ME. 2013. Drought, deluge and declines: the impact of precipitation extremes on amphibians in a changing climate. Biology 2:399–418.

Weir, LA, MJ Mossman. 2005. North American Amphibian Monitoring Program (NAAMP). *In* MJ Lannoo (ed.), Amphibian Declines: The Conservation Status of United States Species, pp. 307–313. University of California Press, Oakland, California.

Youngquist M, Paloski RA, Anderson TL, Badje AF, Burner RC, Casper GS, Davis DR, LeClere JB, Lehtinen R, Engbrecht NJ, Lee YM, Mardis DR, Rainey TA, Roth M, Schindler MC, Watermolen D. In prep. A review of the status and distribution of *Acris blanchardi* in the United States as of 2025. Herpetological Conservation and Biology.

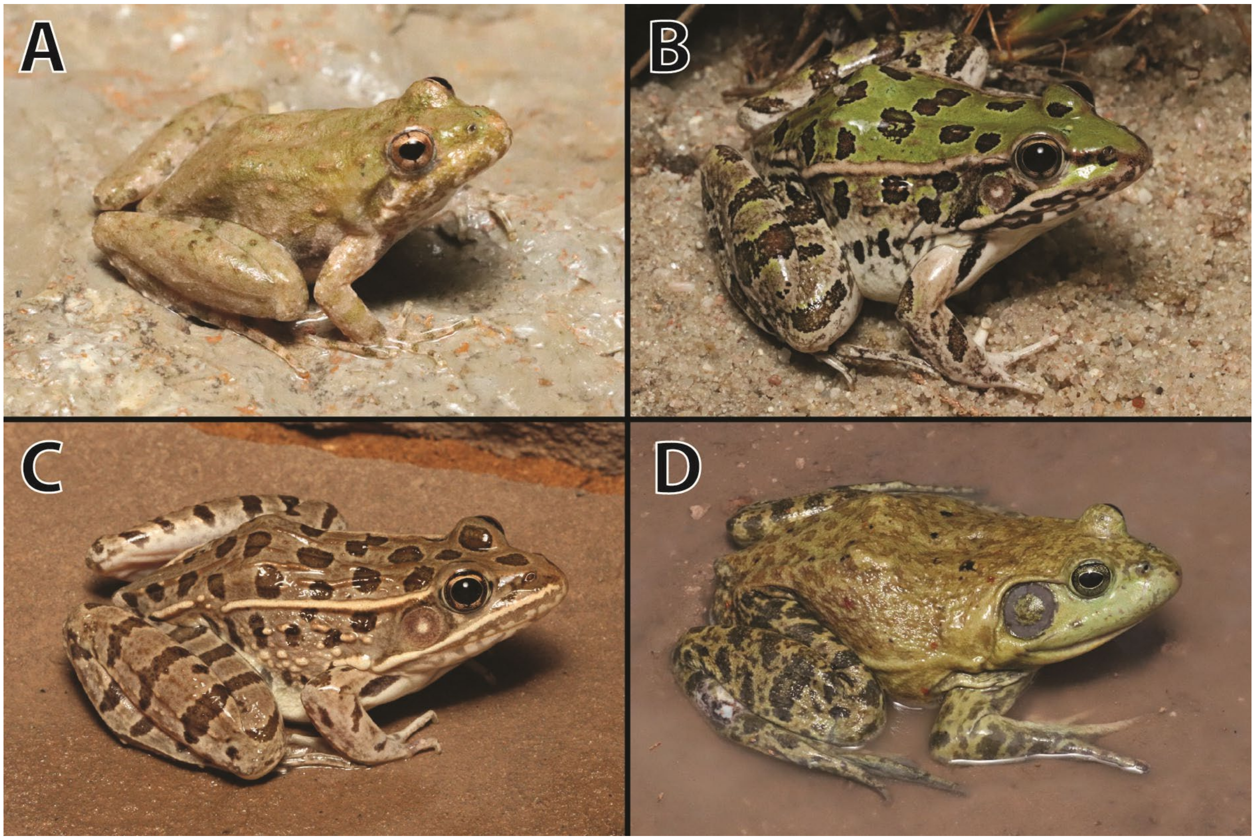

Figure 1. Focal Frog Species. A) Blanchard's Cricket Frog (*Acris blanchardi*) (Species of Greatest Conservation Need [SGCN]); B) Rio Grande Leopard Frog (*Lithobates berlandieri*) (SGCN); C) Plains Leopard Frog (*L. blairi*) (SGCN); American Bullfrog (*Rana* [*Aquarana*] *catesbeiana*) (non-SGCN; invasive along the Pecos River). All photos by Drew Davis.

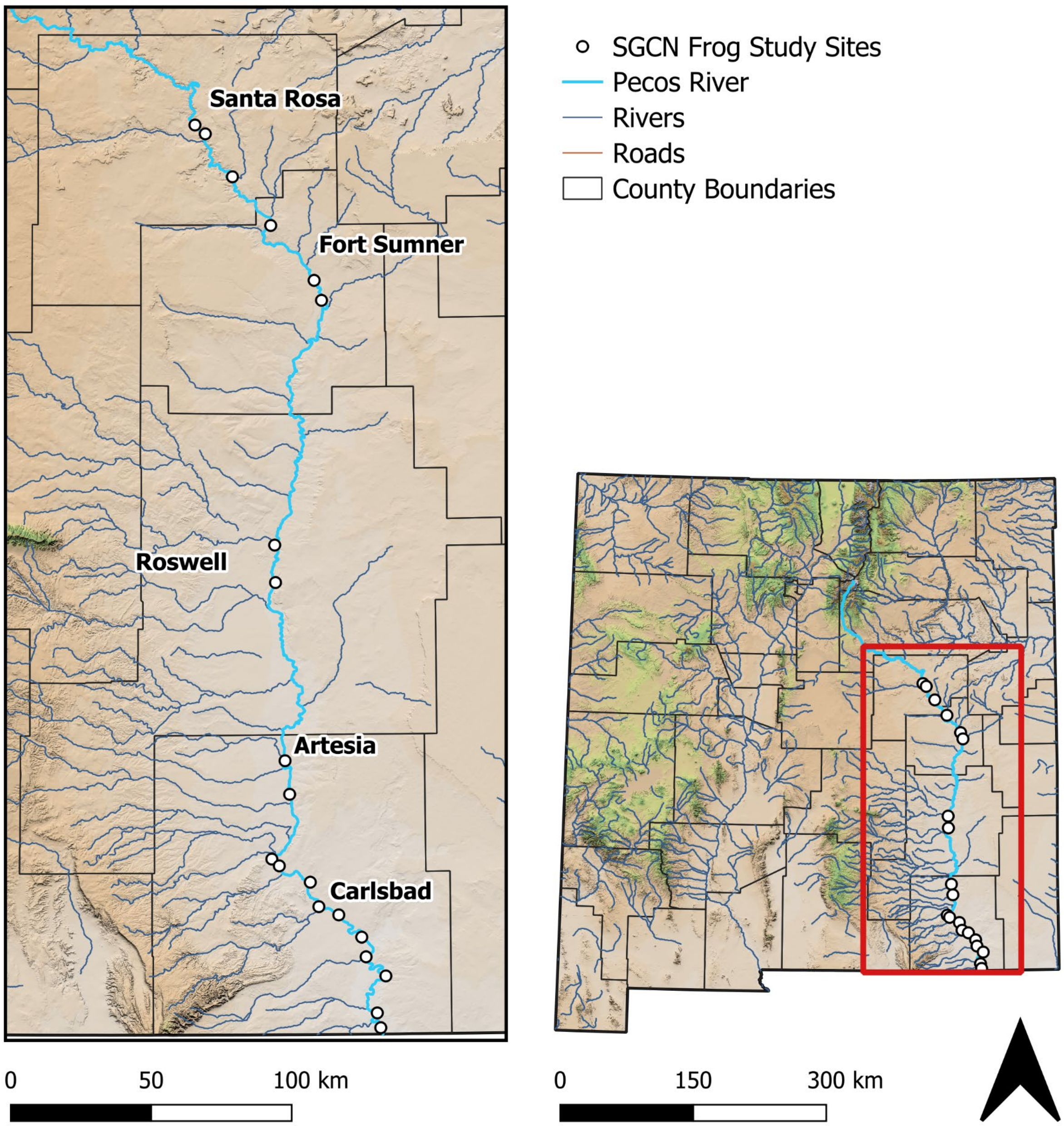

Figure 2. Survey Sites. Map of eastern New Mexico, USA, showing 20 sites along the Pecos River that were sampled for this project (white circles). Sites were selected based on geographic position, public land ownership, and accessibility. The gaps between Fort Sumner and Roswell and Roswell and Artesia are due to the limited quantity of accessible public land in those stretches of the Pecos River.

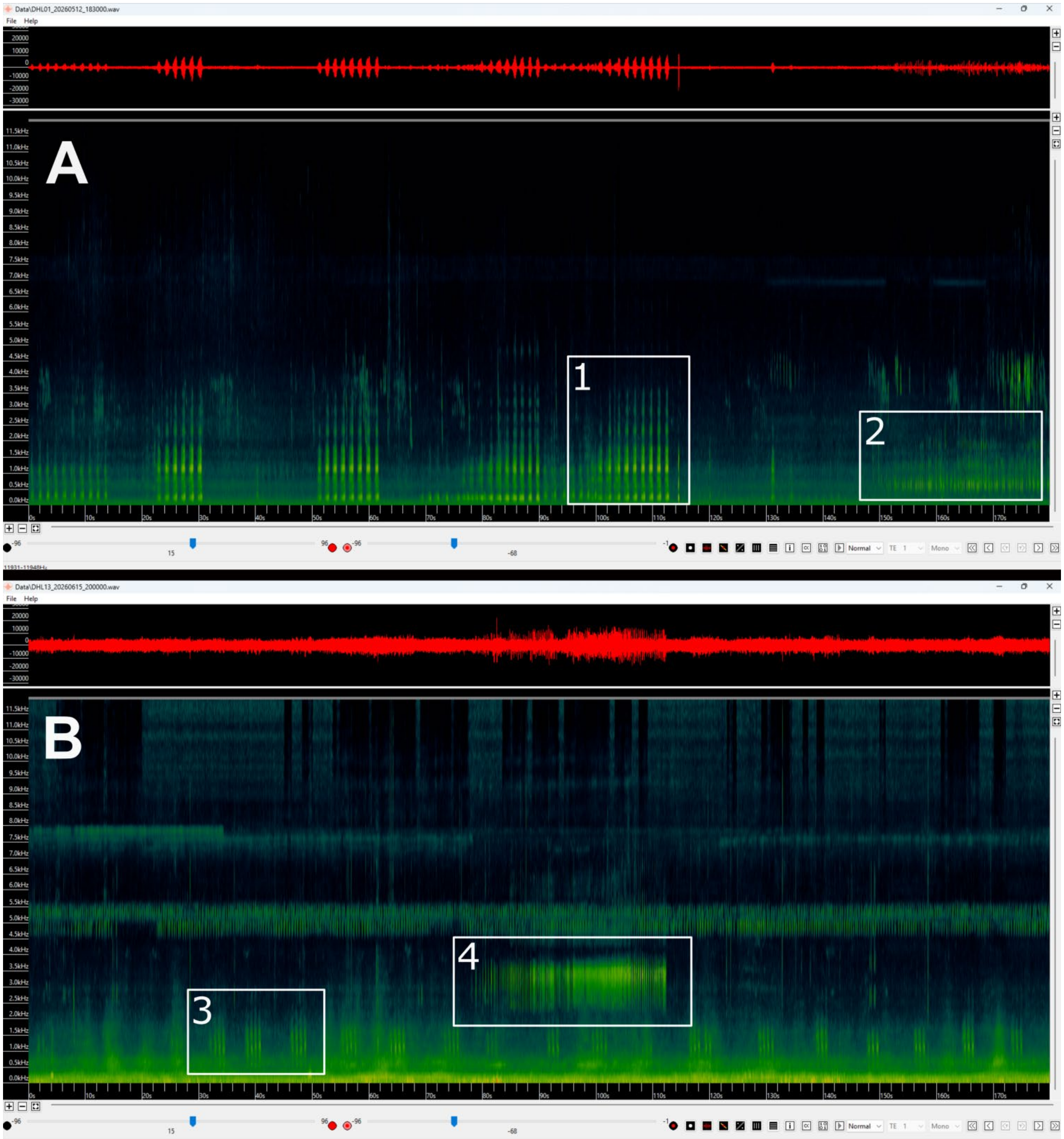

Figure 3. Wildlife Acoustics Kaleidoscope Call Spectrographs for Focal Frog Species. Each window displays an entire 3-min recording, with time on the horizontal axis and frequency (Hz) on the vertical. Color corresponds with call amplitude. Graph A was recorded on Private Land on 12 May 2026. Graph B was recorded at Harroun Crossing on 15 May 2026. Box 1 displays the call of a single male American Bullfrog (*Rana* [*Aquarana*] *catesbeiana*). Box 2 contains the call of a pair of male Plains Leopard Frogs (*Lithobates blairi*). Box 3 contains the call of a single male Rio Grande Leopard Frog (*L. berlandieri*). Box 4 contains the call of a single male Blanchard's Cricket Frog (*Acris blanchardi*).

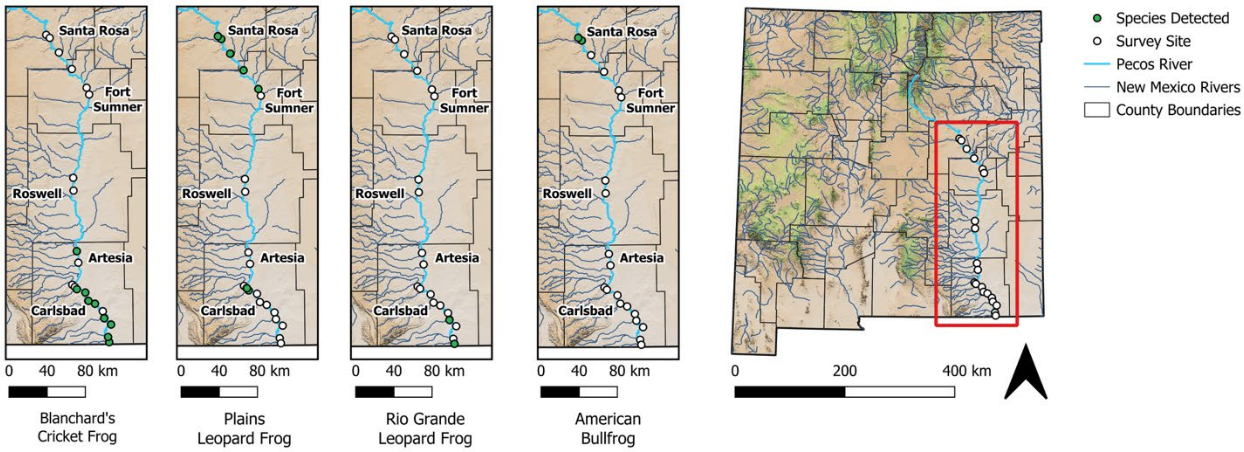

Figure 4. Frog Detections at Survey Sites. Sites were considered positive if a frog was detected by Visual Encounter Survey or Autonomous Recording Unit methods. Surveys were targeting Blanchard's Cricket Frog (*Acris blanchardi*), Plains Leopard Frog (*Lithobates blairi*), Rio Grande Leopard Frog (*L. berlandieri*), and American Bullfrog (*Rana* [*Aquarana*] *catesbeiana*).

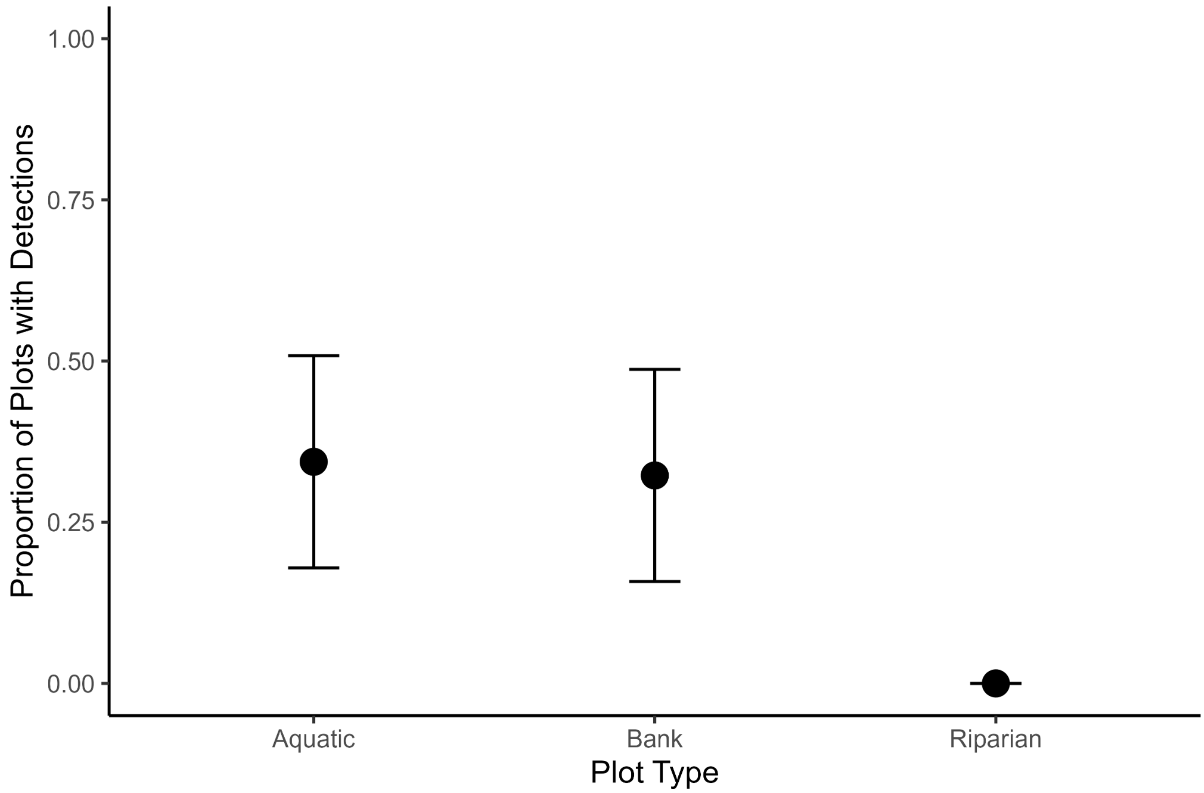

Figure 5. Plot Type Distribution for Blanchard's Cricket Frog (*Acris blanchardi*). The Fisher's Exact Test indicated strong evidence for a difference in plot presence/absence for each microhabitat plot type ($p = 0.0092$). Blanchard's Cricket Frog was observed in bank and aquatic plot types at similar rates, while no individuals were located within riparian plots.

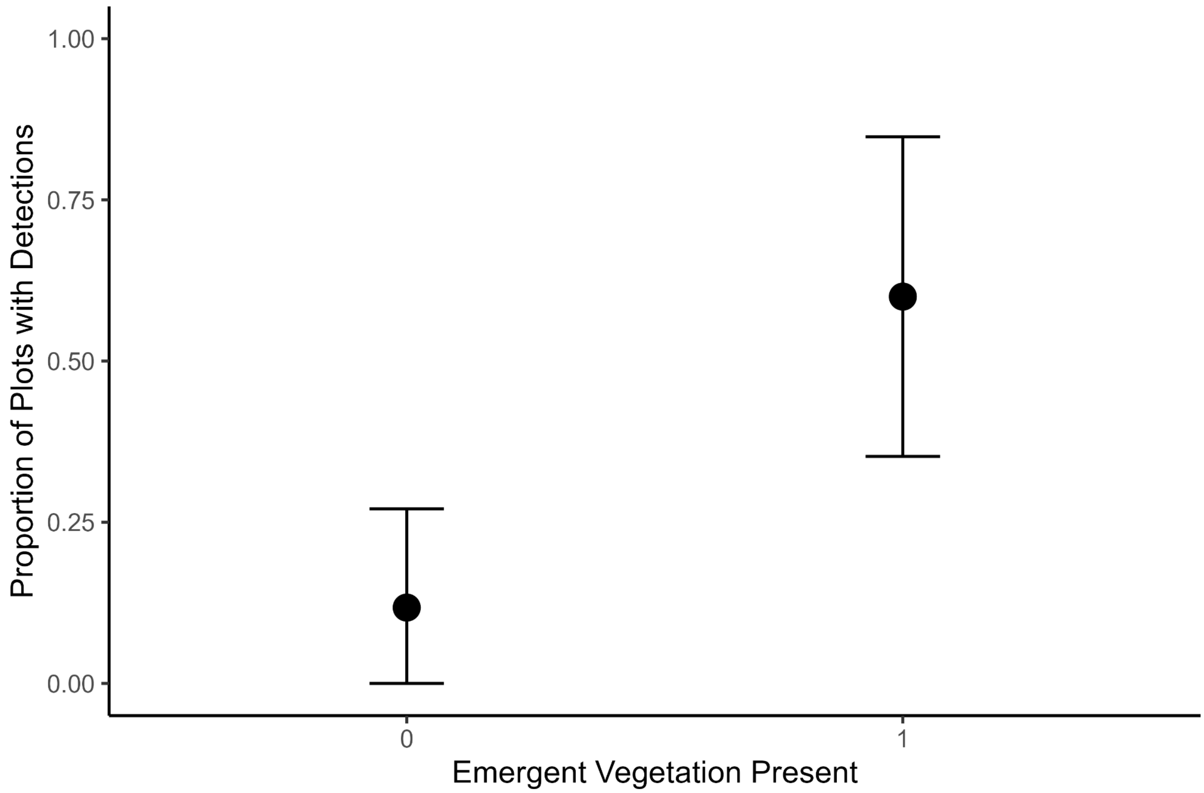

Figure 6. Detection Proportions Associated with Presence of Emergent Vegetation for Blanchard's Cricket Frog (*Acris blanchardi*) in Aquatic Plots. The Fisher's Exact Test indicated strong evidence ($p = 0.008$) for a difference in the presence/absence of emergent vegetation within occupied (1) and background (0) microhabitat plots.

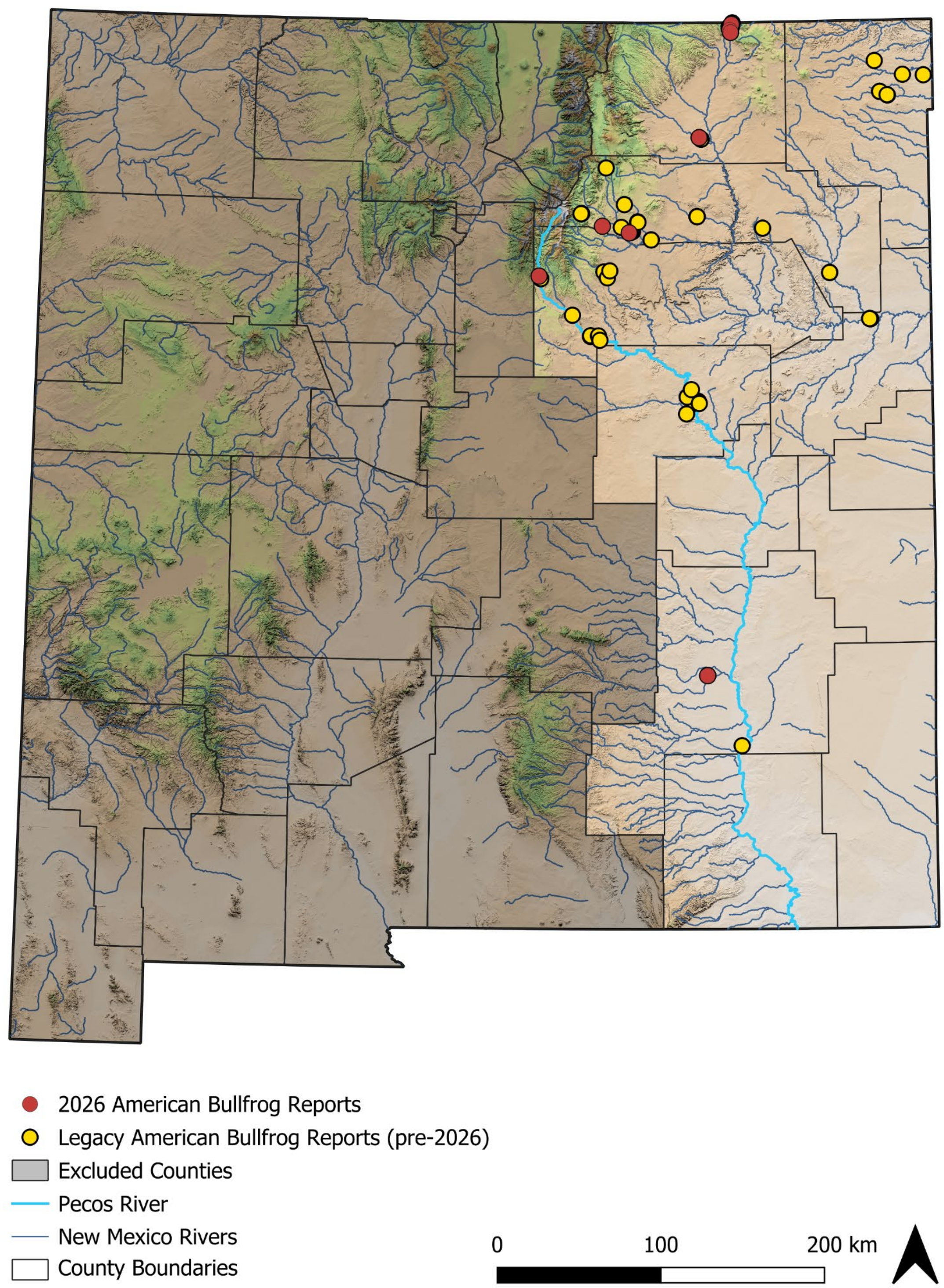

Figure 7. American Bullfrog (*Rana* [*Aquarana*] *catesbeiana*) Reports from the *Frogs of Eastern New Mexico* iNaturalist project. Data from shaded counties was not collected as part of this project.

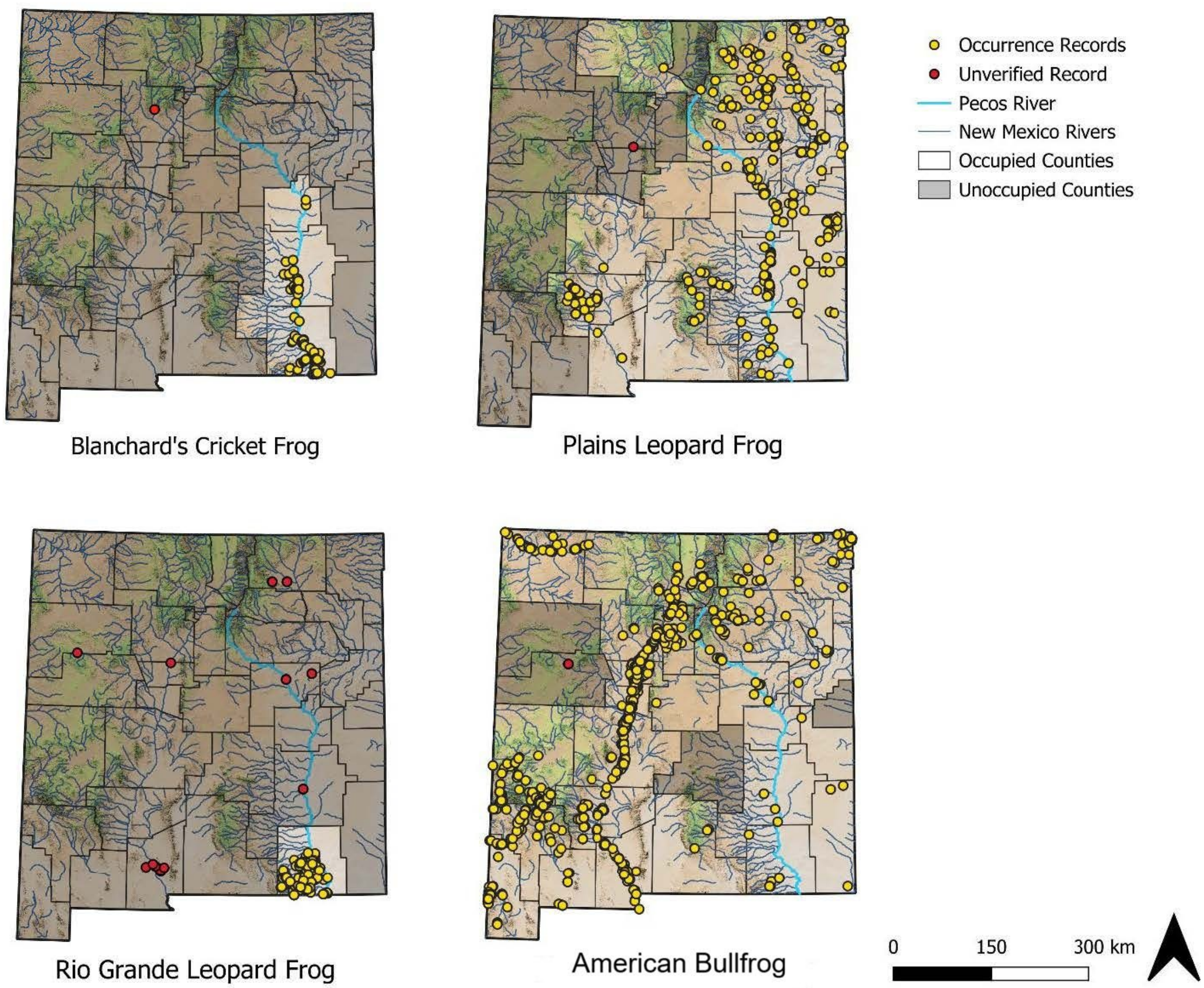

Figure 8. Occurrence Records for Focal Species in New Mexico. Occurrence records were sourced from museum collections and citizen science platforms. Unshaded counties have occurrences for that species according to BISON-M, Degenhardt et al. (1996), or from unpublished, verified records (Drew Davis, unpubl. data). We are following up on several records for each species that fall outside of their known range (red points). Focal species are Blanchard's Cricket Frog (*Acris blanchardi*), Plains Leopard Frog (*Lithobates blairi*), Rio Grande Leopard Frog (*L. berlandieri*), and American Bullfrog (*Rana* [*Aquarana*] *catesbeiana*).

Table 1. Survey Sites. Sites, site codes, survey date, number of observers, and species detected during surveys. Species were detected through either Visual Encounter Surveys or use of Acoustic Recording Units. Species codes: Blanchard's Cricket Frog (*Acris blanchardi*) = ACBL; Rio Grande Leopard Frog (*Lithobates berlandieri*) = LIBE; Plains Leopard Frog (*L. blairi*) = LIBL; American Bullfrog (*Rana* [*Aquarana*] *catesbeiana*) = RACA.

Site Name	Site Code	Survey Date	Observer Count	Species Observed
City of Santa Rosa Water Treatment Facility	CSRW	5/28/2026	2	LIBL RACA
Private Land	PRLA	5/28/2026	2	LIBL RACA
NMSLO Lease	NMSLO	5/29/2026	2	LIBL
Sumner Lake State Park	SLSP	5/29/2026	2	LIBL
Bosque Redondo Park	BORD	5/30/2026	2	LIBL
BLM: Billy the Kid Drive	BTKD	5/30/2026	2	–
Bitter Lake NWR: Salt Creek Wilderness	BLSC	6/17/2026	5	–
Bitter Lake NWR: Main Tract	BLMT	6/17/2026	6	–
W.S Huey Wildlife Management Area	WSHU	6/15/2026	2	ACBL
BLM: Chalk Bluff	CKBF	NA	NA	–
BOR: Brantley Outflow	CPRR	6/11/2026	3	LIBL
BOR: Diving Rock	DIVR	6/11/2026	3	LIBL ACBL
BOR: Avalon Outflow	AVOF	6/16/2026	2	ACBL
Bataan Park	BATP	6/9/2026	3	ACBL
Six Mile Dam	SXMD	6/9/2026	3	ACBL
BLM: Potash Mines Road	PAMR	6/5/2026	3	–
BLM: Harroun Crossing	HACR	6/5/2026	3	LIBE ACBL
BLM: Pierce Canyon	PCCR	6/4/2026	3	ACBL
BLM: Longhorn Road	LNGH	6/4/2026	3	ACBL
BLM: Brushy Draw	BRDW	6/3/2026	3	LIBE ACBL

Table 2. Call Intensity Score. Adapted from Weir and Mossman (2005).

Score	Description
0	No calls observed
1	Individuals can be counted, space between calls
2	Individual calls can be distinguished, some overlap
3	Full chorus, calls are constant, continuous, and overlapping

Table 3. Human Disturbance Severity Score. Categories were defined after initial site visits.

Score	Description
0	No visible human disturbance
1	Minor disturbance: faint footpaths; rare, scattered litter
2	Moderate-light disturbance: Defined paths, some litter
3	Moderate disturbance: well-defined trails, common litter, and/or occasional two-tracks
4	High disturbance: extensive recreational footpaths and two-tracks, obvious anthropogenic erosion, extensive litter
5	Very high disturbance: river channel completely controlled/channelized

Table 4. Salt Cedar (*Tamarix* spp.) Score. Categories were defined after initial site visits.

Score	Description
0	Salt cedar not observed
1	Salt cedar rare, few mature plants
2	Salt cedar present but native shrubs dominant
3	Salt cedar common, close to equal prevalence with native shrubs
4	Salt cedar dominant, greater prevalence than all native shrubs combined
5	Salt cedar completely dominant, no native shrubs present

Table 5. Site Characteristics Variables.

Variable	Description
Rain Past Seven (cm)	Accumulated rainfall (in cm) over the seven days preceding the survey at the nearest National Oceanic and Atmospheric Administration station
Days Since Rain	Days since last rain on the date of the survey
Gauge Height (ft^3/s)	River gauge height (in cubic feet per second) at the nearest U.S. Geological Survey river gauge not separated from the survey location by an impoundment
Gauge Location	The named location of the river gauge used to determine gauge height
Moon Fraction	The fraction of the moon illuminated on the night of the survey
Start Air Temperature (°C)	The air temperature (in °C) at the beginning of the survey
Start Wind Max (km/hr)	The maximum wind speed (in km/hr) detected at the beginning of the survey
Start Relative Humidity	The relative humidity at the beginning of the survey
Salt Cedar Score	The salt cedar (*Tamarix* spp.) score for the site, see Table 4
Vegetation Rank 1	The most prevalent vegetation type present at the site (herbaceous, emergent, floating, submerged, woody, woody debris)
Vegetation Rank 2	The second most prevalent vegetation type present at the site (herbaceous, emergent, floating, submerged, woody, woody debris)
Vegetation Rank 3	The third most prevalent vegetation type present at the site (herbaceous, emergent, floating, submerged, woody, woody debris)
Human Disturbance Severity Score	The human disturbance severity score for the site, see Table 3
OHV Use Present	Whether signs of OHV use (trails, two-tracks, associated bank erosion) are present at a site
Livestock Sign Present	Whether signs of livestock (cattle, tracks, grazed vegetation, feces, associated bank erosion) are present at a site
Bullfrog Present	Whether American Bullfrogs were detected (by Visual Encounter Survey or Autonomous Recording Unit) at a site

Table 6. Microhabitat Variables.

Variable	Description
Plot Type	The class of each frog or background plot. Aquatic ($-2 \leq x < 0$), Bank ($0 \leq x < 2$), Riparian ($2 \leq x \leq 5$)
Flow	The flow speed (in km/hr) of the water at the center of the microhabitat plot (aquatic plots only)
Substrate	The substrate type at the center of the microhabitat plot (dirt, sand, gravel, rock)
Moisture	The moisture class of the substrate at the center of the microhabitat plot (dry, moist, wet, submerged; USDA 1998)
Percent Low Cover	The percentage of the 1-m diameter plot covered by low objects a frog may use as shelter
Low Cover Type	The types of low cover within the plot (emergent vegetation, herbaceous vegetation, woody vegetation [woody shrubs and woody debris], aquatic vegetation [floating or submerged vegetation], abiotic [rock or undercut])
Percent Overstory Cover	The cover percentage of the canopy above the plot, as measured with a spherical densiometer
Overstory Cover Type	The types of overstory cover within the plot. Trees were identified to genus when possible.
Slope	The slope (in degrees) of the substrate at the center of the microhabitat plot (bank and riparian plots only)
Surface Temperature	The temperature (in °C) of the substrate at the center of the microhabitat plot, measured during the nocturnal survey (bank and riparian plots only)
Water Temperature	The temperature (in °C) of the water at the center of the microhabitat plot, measured during the nocturnal survey (bank and riparian plots only)
Depth	The depth (in cm) of the water at the center of the microhabitat plot (aquatic plots only)
pH	The pH of the water at the center of the microhabitat plot (aquatic plots only)
Conductivity	The conductivity (in μS/cm) of the water at the center of the microhabitat plot (aquatic plots only)

Table 7. Summarized Morphometrics for Four Focal Species of Frogs. Species codes: Blanchard's Cricket Frog (*Acris blanchardi*) = ACBL; Rio Grande Leopard Frog (*Lithobates berlandieri*) = LIBE; Plains Leopard Frog (*L. blair*i) = LIBL; American Bullfrog (*Rana* [*Aquarana*] *catesbeiana*) = RACA.

Species	Quantity	Average SVL (mm)	Average Mass (g)	Male	Female	Juvenile
ACBL	25	25.3	1.57	20	2	3
LIBE	1	74	41.41	1	0	0
LIBL	2	85.5	60.23	0	2	0
RACA	12	106.9	149.17	3	6	3

Table 8. Fisher's Exact Test Results for Site Presence/Absence. Species codes: Blanchard's Cricket Frog (*Acris blanchardi*) = ACBL; Rio Grande Leopard Frog (*Lithobates berlandieri*) = LIBE; Plains Leopard Frog (*L. blair*i) = LIBL; American Bullfrog (*Rana* [*Aquarana*] *catesbeiana*) = RACA.

Variable	ACBL p-value	LIBL p-value	LIBE p-value	RACA p-value
Vegetation Rank 1	0.734785	1	0.500645	1
Vegetation Rank 2	0.809045	0.284211	1	1
Vegetation Rank 3	0.757864	0.873684	0.699071	0.615789
OHV Use Present	1	1	0.270175	1
Livestock Sign Present	1	0.447368	1	1
Bullfrog Present	0.473684	1	0.110526	–

Table 9. Blanchard's Cricket Frog (*Acris blanchardi*) Mann-Whitney U test Results for Site Presence/Absence. W is the Wilcoxon rank-sum statistic from the Mann-Whitney U test.

Variable	W	p-value	Frog Absent Median	Frog Present Median
Salt Cedar Score	52.5	0.876	3	2.5
Human Disturbance Severity Score	36	0.292	2	3
Rain Past Seven (cm)	55	0.474231	3.73	3.02
Days Since Rain	31.5	0.240109	0	1
Gauge Height (ft^3/s)	52	0.272095	68.3	29.7
Moon Fraction	52	0.633309	0.79	0.41
Start Air Temperature (°C)	29	0.210604	23.8	28.6
Start Wind Max (km/hr)	57.5	0.358319	5.4	2.1
Relative Humidity	27	0.15743	41.2	54.5

Table 10. Plains Leopard Frog (*Rana blairi*) Mann-Whitney U-test Results for Site Presence/Absence. W is the Wilcoxon rank-sum statistic from the Mann-Whitney U test.

Variable	W	p-value	Frog Absent Median	Frog Present Median
Salt Cedar Score	43.5	0.902456	3	3
Human Disturbance Severity Score	42	0.806364	2	3
Rainfall Past Seven (cm)	41.5	0.759191	5.7	3.56
Days Since Rain	48.5	0.314215	1	0
Gauge Height (ft^3/s)	33.5	0.926106	52.1	68
Moon Fraction	19.5	0.125345	0.41	0.91
Start Air Temperature (°C)	38	1	26.1	23.8
Start Wind Max (km/hr)	29	0.48151	2.8	8.1
Relative Humidity	51	0.266125	51.6	40.7

Table 11. Rio Grande Leopard Frog (*Rana berlandieri*) Mann-Whitney U-test Results for Site Presence/Absence. W is the Wilcoxon rank-sum statistic from the Mann-Whitney U test.

Variable	W	p-value	Frog Absent Median	Frog Present Median
Salt Cedar Score	19.5	0.896641	3	2.5
Human Disturbance Severity Score	22.5	0.603328	2.5	2
Rainfall Past Seven (cm)	12	0.727823	3.73	3.02
Days Since Rain	7	0.703303	0	1
Gauge Height (ft^3/s)	12	0.6475	67.2	41.3
Moon Fraction	4	0.384268	0.79	0.92
Start Air Temperature (°C)	14	0.6	26.1	23.2
Start Wind Max (km/hr)	14	0.484408	3.9	1.4
Relative Humidity	2	0.3	48.8	70.5

Table 12. American Bullfrog (*Rana* [*Aquarana*] *catesbeiana*) Mann-Whitney U-test Results for Site Presence/Absence. W is the Wilcoxon rank-sum statistic from the Mann-Whitney U test.

Variable	W	p-value	Frog Absent Median	Frog Present Median
Salt Cedar Score	18	1	3	2.5
Human Disturbance Severity Score	33	0.059615	3	1
Rainfall Past Seven (cm)	20	0.849603	3.73	3.56
Days Since Rain	27	0.239617	0.5	0
Gauge Height (ft^3/s)	16	0.94695	54.4	67.2
Moon Fraction	10	0.343066	0.6	0.91
Start Air Temperature (°C)	22	0.673684	26.35	23.75
Start Wind Max (km/hr)	4	0.08645	2.75	11.15
Relative Humidity	24	0.515789	51.55	40.95

Table 13. Fisher's Exact Test Results for Microhabitat Features in Aquatic Plots. Species codes: Blanchard's Cricket Frog (*Acris blanchardi*) = ACBL; American Bullfrog (*Rana* [*Aquarana*] *catesbeiana*) = RACA. Significant values shown in bold.

Variable	ACBL p-value	RACA p-value
Substrate	0.81	0.54
Emergent Vegetation Present	**0.008**	1
Herbaceous Vegetation Present	1	0.26
Woody Vegetation Present	0.4	0.46
Aquatic Vegetation Present	0.53	Not enough observations
Abiotic Cover Present	1	0.27

Table 14. Fisher's Exact Test Results for Microhabitat Features in Bank Plots. Species codes; Blanchard's Cricket Frog (*Acris blanchardi*) = ACBL; American Bullfrog (*Rana* [*Aquarana*] *catesbeiana*) = RACA. Significant values shown in bold.

Variable	ACBL p-value	RACA p-value
Substrate	0.2	0.47
Moisture	0.18	0.12
Emergent Vegetation Present	**0.0075**	0.12
Woody Vegetation Present	1	1
Herbaceous Vegetation Present	0.11	0.4
Abiotic Cover Present	0.15	0.4
Aquatic Vegetation Present	0.32	0.13

Table 15. Blanchard's Cricket Frog (*Acris blanchardi*) Mann-Whitney U-test Results for Microhabitat Feature Associations within Aquatic Plots. Significant values shown in bold. W is the Wilcoxon rank-sum statistic from the Mann-Whitney U test. Though median flow did not differ between plots where Blanchard's Cricket Frogs were present or absent due to a relatively small quantity of plots containing flowing water, comparison of means (mean present = 0 km/hr; mean absent = 0.455 km/hr), the small p-value, and the complete absence of frog detections in flowing water provide strong evidence for an association between Blanchard's Cricket Frog presence and still water.

Variable	W	p-value	Frog Absent Median	Frog Present Median
Flow (km/hr)	159.5	**0.012**	0	0
Percent Low Cover	95	0.422	50	75
Percent Overstory Cover	105	0.188	0	0
Water Temperature (°C)	44.5	**0.011**	27	28.25
Depth (cm)	154.5	**0.038**	0.39	0.1
pH	81	0.308	8.2	8.3
Conductivity (µS/cm)	102	0.917	4273	6373

Table 16. Blanchard's Cricket Frog (*Acris blanchardi*) Mann-Whitney U-test Results for Microhabitat Feature Associations within Bank Plots. W is the Wilcoxon rank-sum statistic from the Mann-Whitney U test.

Variable	W	p-value	Frog Absent Median	Frog Present Median
Percent Low Cover	132.5	0.251	60	40
Percent Overstory Cover	115	0.346	0	0
Surface Temperature (°C)	89	0.512	24.1	23.55
Slope (degrees)	144.5	0.099	16	10

Table 17. American Bullfrog (*Rana* [*Aquarana*] *catesbeiana*) Mann-Whitney U-test Results for Microhabitat Feature Associations within Aquatic Plots. W is the Wilcoxon rank-sum statistic from the Mann-Whitney U test.

Variable	W	p-value	Frog Absent Median	Frog Present Median
Flow (km/h)	16	0.674	0	0
Percent Low Cover	24	0.719	55	20
Percent Overstory Cover	12	0.101	0	0
Water Temperature (°C)	12.5	0.251	19.55	19.9
Depth (cm)	28	0.352	0.33	0.17
pH	28.5	0.212	8.35	8.2
Conductivity (µS/cm)	28.5	0.212	2326	2278

Table 18. American Bullfrog (*Rana* [*Aquarana*] *catesbeiana*) Mann-Whitney U-test Results for Microhabitat Feature Associations within Bank Plots. Significant values shown in bold. W is the Wilcoxon rank-sum statistic from the Mann-Whitney U test.

Variable	W	p-value	Frog Absent Median	Frog Present Median
Percent Low Cover	22	**0.038**	77.5	42.5
Percent Overstory Cover	9	0.307	0	0
Surface Temperature (°C)	12	1	19.1	18.95
Slope (degrees)	19.5	0.133	16	5.5

Table 19. Model Results for Call Activity and River Gauge Height. Species codes: Blanchard's Cricket Frog (*Acris blanchardi*) = ACBL; Plains Leopard Frog (*Lithobates blairi*) = LIBL; Rio Grande Leopard Frog (*L. berlandieri*) = LIBE; American Bullfrog (*Rana* [*Aquarana*] *catesbeiana*) = RACA. Significant values shown in bold.

Species	Model Type	ΔAIC	Gauge Model Coefficient	p-value
ACBL	CLMM	1.02	-0.0010890	0.3285
LIBL	CLMM	5.17	-0.0015867	**0.0060**
LIBE	GLMM	2.90	0.4153600	**0.0260**
RACA	CLMM	1.28	0.0005651	0.4352