American Bullfrog Eradication in Sycamore Canyon, Arizona, a Natural Open Aquatic System

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Arizona was once home to six native ranid frog species (seven including the Ramsey Canyon Leopard Frog). Of these, the Tarahumara Frog (*Rana tarahumarae*) and the Relict Leopard Frog (*Rana onca*) have been extirpated and later reintroduced, while the other native ranids have all suffered from population declines and range reduction. The causes most often cited are the usual ones, including introduced predators (particularly fish), habitat loss, drought, and disease. Of all of these species, including the reintroduced species with populations that number only in the hundreds of individuals, only the Chiricahua Leopard Frog (*Rana chiricahuensis*) has received federal protection as a Threatened species.

In addition to the natives, two ranid frog species have been introduced into Arizona. The Rio Grande Leopard Frog (*Rana berlandieri*) was introduced in the 1960s or 1970s into Painted Rock Reservoir on the Gila River. As the Rio Grande Leopard Frog range expands through the Colorado, Gila, and Salt Rivers, competition is expected to occur with the Lowland Leopard Frog (Rorabaugh et al. 2002).

The other non-native ranid, the American Bullfrog (*Rana catesbeiana*) was introduced as a game species at an unknown date, presumably around 1900. The frog has since proven a formidable predator and competitor to native frogs, and has been cited as the primary cause of the disappearance of populations of native frogs in many localities. Bullfrogs now occupy nearly every substantial permanent body of water in the state, are capable of remarkable population densities, and have been found to disperse distances of at least 6.8 miles across open grassland (Suhre unpublished data). High population densities are supported by the ability of adult frogs to sustain themselves on juvenile frogs when necessary, as well as the lack of appropriate predators. Most fish find bullfrog tadpoles distasteful (Kruse and Francis 1977, Smith et al. 1999), and the larger aquatic predators such as snakes and wading birds that feed on bullfrogs in their native range are absent or present in low numbers in the arid Southwest.

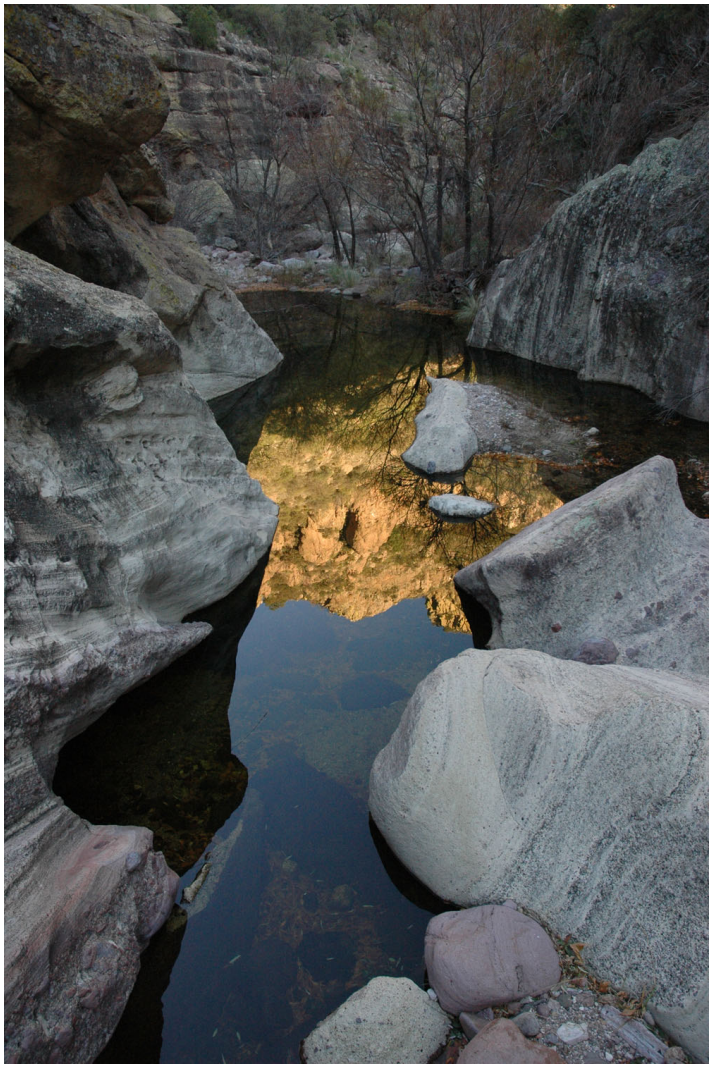

Figure 1. Sycamore Canyon, Pajarito Mountains, Arizona, December 2004. Photo by David A. Kahrs.

The Chiricahua Leopard Frog (CLF) now exists in two disjunct population segments, which may be distinct species (USFWS 2005). The northern population occurs in the Mogollon Rim region into New Mexico, and the southern population ranges through the "Sky Island" region of southern Arizona into the Sierra Madre in Mexico. Little is known of the status of the species in Mexico.

The Pajarito-Atascosa Mountain complex in Santa Cruz County contains what is perhaps the most robust remaining CLF metapopulation in the US, and likely in its remaining geographic range (P. Rosen, pers. comm.). The metapopulation is also potentially connected with CLFs present in Buenos Aires National Wildlife Refuge and other sites in the Altar Valley, although many of these sites have been invaded by bullfrogs. The region as a whole has been designated as a distinct Recovery Unit in the recently released Draft Recovery Plan.

Within the Pajaritos, much of the remaining CLF habitat is provided by man-made stock tanks. Central to the health and persistence of the metapopulation is Sycamore Canyon, as the largest perennial natural aquatic system in the area and home to a thriving (relative to many other sites) CLF population. The canyon was at one time home to three native ranid frogs. The Lowland Leopard Frog and Tarahumara Frog were last documented there in the 1970s. Heavy metal pollution was cited as a potential cause at the time (Hale et al. 1995), although recent research into the history and origins of the fungal disease chytridiomycosis suggests that it may have been an important factor (Bradley et al. 2002). The canyon also supports high densities of another Threatened aquatic species, the Sonora Chub (*Gila ditaenia*).

In May of 2004, I passed through southern Arizona on my way to a field job in California. I spent a night camping in the parking lot at Sycamore Canyon, and heard bullfrogs calling. As a California native familiar with the impacts of bullfrogs on native frog populations, I was of course disturbed. However, this was prior to my familiarity with the present state of affairs in Arizona amphibian conservation, and I assumed this was just one more site that had been "lost". Upon arriving in Tucson in the fall of that year to begin an MS project examining predator/prey relationships within the vertebrate and invertebrate community in Cienega Creek, I learned of the potential seriousness and hope for the situation in Sycamore Canyon. I returned to the canyon in December of that year, and observed what appeared to be small bullfrog tadpoles throughout the part of the canyon that I visited. Identification was confirmed from photographic records, and for what appeared to be the first documented time, the bullfrog was established and reproducing in Sycamore Canyon.

Figure 2. Chiricahua Leopard Frog, Sycamore Canyon, July 2005. Photo by David A. Kahrs.

Figure 3. Seining American Bullfrog tadpoles in Sycamore Canyon, June 2005. Photo by David A. Kahrs.

The 2004-2005 winter was unusually wet, and on an April visit to the canyon, I found bullfrog tadpoles throughout almost the entire canyon, apparently having been carried by the stream flow a distance of up to 4 miles from the nearest point that I found adults of reproductive size. Only a small series of pools, the last before the stream dried up near the border, remained free of bullfrogs. While much of the canyon appeared unsuitable for bullfrog reproduction due to intermittent drying and the potential for scouring floods, the dispersal abilities of the species put the entire CLF population at risk of predation by adult bullfrogs. Eradication seemed to be imperative.

By one of the few strokes of good fortune to befall me that summer, a friend from my undergraduate program had graduated in May of 2005 and wanted to relax for a summer of herping in Arizona before entering into his own graduate research on pit viper systematics at the University of Texas at Tyler. So, upon his arrival in Tucson, he was immediately drafted as a volunteer into the eradication attempt.

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Most if not all successful bullfrog eradication efforts have involved closed and generally man-made systems. Stock tanks can be securely fenced and pumped dry during the summer, eliminating every bullfrog with complete confidence. If reintroduction can be prevented, this method can be very effective in regaining aquatic habitat for native species recovery. However, to our knowledge no eradication campaign has been attempted in a situation similar to Sycamore Canyon, as an open natural system. Obviously any methods used would have to be completely manual and minimally invasive due to the presence of two Threatened species.

We used seines as the primary method in removing tadpoles. We seined each pool multiple times on a visit, until we began to catch fewer than 10 tadpoles per sweep. During the initial phase of the eradication last summer, complete removal was not feasible, so we directed our efforts towards removing the greatest number of tadpoles possible. In one pool for instance, we seined perhaps 15 times in an afternoon, but continued to remove large numbers of tadpoles. We removed approximately 500 tadpoles that day, only to return the following week to find that the pool had rapidly dried and our work had been unnecessary. However, during the course of the summer we removed over 7000 bullfrog tadpoles. During the same period, we only encountered 317 CLF tadpoles.

The eradication was facilitated in most ways by the late onset of the monsoon. Despite the high water levels (very much higher than this year), many pools dried completely, and many of those remaining were greatly reduced in size, making our work much easier. It also appeared that the CLFs, as one would expect, were much better adapted to the timing of summer drying. In the pool mentioned above, the bullfrog tadpoles were far from metamorphosis. However, we also captured 13 CLF tadpoles in the same pool. Nearly all of them had complete hind legs and had begun resorption of the tail. Few CLF tadpoles seemed in danger of dying in drying pools.

Adult and metamorph bullfrogs were removed by hand capture and shooting. We used a BB gun for most of the summer, which was effective on the smaller frogs. It was fatal for the larger frogs as well, although they were often able to escape into the water and prevent confirmation of their removal. Few large, breeding adult frogs were found, although two gravid females were captured and removed, thus stopping breeding events that would have compounded the problems we still face. As not every frog shot was recovered, an exact count of adult and metamorph removal is not available although the number probably exceeded 500.

Crews from AZGFD were also involved in bullfrog removal intermittently during the summer. Finally, a large volunteer effort was scheduled in which we hoped to remove nearly all of the bullfrogs from the canyon. The AZGFD crew with approximately 12 volunteers and I arrived at the campsite only to find that the first storms of the monsoon were beginning. I entered the canyon that night to conduct my usual evening work eradicating adults and metamorphs, only to find that the first rain apparently triggered a massive dispersal event. Pools that the week before had perhaps hundreds of metamorph bullfrogs had a mere handful. I found fewer than 20 frogs that night instead of the masses I had expected. However, the dispersal seemed to be mostly unidirectional as few frogs were present after the monsoon.

Figure 4. Dead Chiricahua Leopard Frog in Sycamore Canyon, presumably killed by the chytrid fungus. Photo by David A. Kahrs.

The work continues this summer. I observed many dead frogs this winter, presumably chytrid-killed, although all were in the upper canyon. We have installed i-buttons in several pools in the canyon to get a temperature profile and an idea of the degree of difference between the areas with and without die-offs. A large-scale CLF site monitoring project is also underway with volunteer help to visit satellite populations in tanks within the Pajaritos. Any that seem in immediate danger of drying may be salvaged. My eradication work will continue in the canyon, as a few frogs still remain as well as tadpoles in some pools. Two bullfrogs managed to reproduce last summer in Sycamore Canyon, although it was detected early and most of the tadpoles were removed last fall.

For a project such as this, removal must be 100% to be of any value at all. If one bullfrog manages to reproduce while our backs are turned, and the several thousand tadpoles are spread by stream flow again, the work will have been nearly completely undone. Once dispersal from potential sources such as Ruby Lakes and other tanks in the area becomes a possibility during the monsoon, regular nocturnal frog surveys will be a must to ensure that no more breeding takes place. Until the source populations have been dealt with, a massive undertaking which is just now coming under serious discussion, continuing immigration of bullfrogs to Sycamore Canyon remains a distinct possibility.

Figure 5. Using a BB gun to eradicate the non-native American Bullfrog from Sycamore Canyon. Photo by David A. Kahrs.

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