# A Critical Interim Evaluation of the Effectiveness of Bullfrog Removal Methods at San Bernardino National Wildlife Refuge

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**on the challenge cost share project**

**Bullfrog Impacts on Native Wetland Herpetofauna**

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## Executive Summary


This report summarizes and updates bullfrog removal efforts at San Bernardino National Wildlife Refuge (SBNWR), Cochise County, Arizona for 1995. It provides a thorough re-evaluation of these efforts based on the data accumulated 1985-1995, and consistent with results to July 1996. The focus of the work has been the apparent negative effect of introduced bullfrogs (*Rana catesbeiana*) on native Mexican garter snakes (*Thamnophis eques*) and Chiricahua and lowland leopard frogs (*R. chiricahuensis*) and (*R. yavapaiensis*). Leopard frogs disappeared from the refuge early in this project, after having persisted marginally for some years of our observation. Mexican garter snakes have declined from already-low population densities during the years of the project, despite bullfrog removals. All of this basic information is summarized in the published literature (Rosen and Schwalbe, 1995) and in a previous report (Rosen and Schwalbe, 1996).

Early bullfrog removal protocols (1985-1989) were not intensive enough to cause a persistent decline in bullfrog population sizes, although a weak increase in garter snake trapping returns was observed prior to 1990 (Schwalbe and Rosen, 1988). After a two year hiatus, work

was resumed in 1992-present. Removals were intensified during 1993 and 1994, using continuous trapping throughout the primary active season to remove bullfrogs. This protocol has produced a persistent reduction in bullfrog populations and especially in biomass. Most adults are removed using the traps, and juveniles are removed as they mature. Reproduction has been reduced not eliminated.

Results in 1995 indicate that continued trapping with the protocol used in 1994 and 1995 is unlikely to result in continuing decline of the bullfrog population. Biomass removal in 1995 was similar to that for 1994, with very similar removal effort. This fails to show the hoped-for steady decline. This trend was apparent across the board at sites on the refuge. Similarly, there was no further decline in the mean size of removed bullfrogs at SBNWR in 1995, suggesting that effectiveness of the methods used is limited. Young bullfrogs are still maturing and reproducing prior to being captured and removed. Under these circumstances, juvenile bullfrog survivorship appears to be high.

Mexican garter snakes reproduced successfully in 1993-4 in one of the intensive bullfrog removal areas, apparently in response to an unusually successful bullfrog removal. Although this response was statistically significant, it was not very strong, and was not continued in 1995. This species continues to decline toward local extinction on the refuge. It appears to be threatened by bullfrogs in southeastern Arizona, and presumably also in central Arizona, where it is uncommon. It is extremely rare in New Mexico, and may be headed for extirpation from the United States.

The checkered garter snake (*T. marcianus*), less aquatic than the Mexican garter snake, appears to be maintaining large population size and successful reproduction on the refuge. The Sonoran mud turtle population at SBNWR is unusually small, for reason(s) unknown. There has been recruitment during our study, suggesting a possibly increasing population. We continued our investigation of bullfrog diet during 1995, and obtained the first record confirming consumption of the Mexican garter snake by bullfrogs on the refuge.

Another phase of this project involves direct management of two native Chiricahua leopard frog populations, which are at bullfrog-free stock ponds on a ranch close to SBNWR. In cooperation with AGFD, USFWS, and the Malpai Borderlands Group (a rancher association for the San Bernardino-San Simon-Animas valleys region), we have established an enclosed leopard frog population on the refuge (bullfrogs excluded) using frogs from one of the ranch ponds. Also in cooperation with the above entities, we have monitored the naturally existing leopard frogs. The leopard frogs that were re-established on the refuge bred successfully at an age of only 4 mo post-metamorphosis, in September 1994. Some of the originally-introduced individuals, and a number of the 1994 spawn reproduced again in September 1995. Monitoring results consistently indicated a tripling of the enclosure population from 1994 to 1995.

On the Magoffin Ranch, a combination of private work by the Magoffins, funding from the Malpai Borderlands Group, and an AGFD Stewardship Grant have combined to sustain three subpopulations of the Chiricahua leopard frog. Another population, slightly farther east, in Guadalupe Canyon, appears to have disappeared during the drought. We present monitoring data and natural history observations for these populations, as well as for the refuge population at Leslie Canyon, Swisshelm Mountains.

## INTRODUCTION AND BACKGROUND

This report summarizes results of ongoing bullfrog removal efforts at San Bernardino National Wildlife Refuge for 1995. Project objectives are to (1) evaluate the feasibility of bullfrog removal as a means of control of this introduced species, (2) determine whether the introduced bullfrog is responsible for declines of native herpetofauna (Hayes and Jennings, 1986), specifically Chiricahua and lowland leopard frogs and Mexican garter snake, and (3) determine whether control of bullfrogs leads to population recovery of affected native species (Schwalbe and Rosen, 1988; Rosen and Schwalbe, 1995). In addition, the project aims to (4) assist recovery of Chiricahua leopard frog populations in the Cochise County area.

The first phase of the project (1985-9), primarily involved two or three trips a year of 3-4 days duration to remove bullfrogs from SBNWR. Results suggested weak positive effects of bullfrog removals on garter snakes (below, and Schwalbe and Rosen 1988); however, bullfrog populations recovered from removals within less than a year. The second project phase was initiated in 1992 after a two-year hiatus. Effort was intensified beginning May 1993, involving manual removals of bullfrogs by approximately 14-18 persons from University of Arizona and Arizona Game & Fish Department, as well as by lengthy trapping periods for bullfrogs during much of their active season. Trapping was conducted jointly by USFWS and University of Arizona personnel during June-November 1993, March-October 1994, and May-October 1995.

In 1994 we initiated a third phase of the project involving active preservation and management of Chiricahua leopard frog populations at and near the refuge. This work was in collaboration with SBNWR, AGFD Nongame Branch, and the Malpai Borderlands Group (MBG). We assisted in preserving leopard frog populations at Rosewood Tank, 7 mi east of the refuge, and Belency Tank, along the border at 5 mi east of the refuge, both on the Magoffin Ranch. Rosen, Magoffin, and Cobble conducted regular and frequent visual surveys of the leopard frogs, and the Magoffins managed waters to forestall habitat drying. Rosen and other UA personnel additionally surveyed the surrounding region, and monitored Chiricahua leopard frogs in the next nearest known population site, Guadalupe Canyon.

Principal investigators, refuge managers, and AGFD Nongame Branch personnel collaborated in a frog re-establishment project during 1994, in which a portion of the tadpoles from Rosewood Tank were removed before the tank dried, and relocated to a pond-enclosure system created for them on the refuge (Rosen and Schwalbe, 1996).

## BULLFROG REMOVAL AND ABUNDANCE

**Overview of Removal Program.** Removal methods, which have been detailed elsewhere (Schwalbe and Rosen, 1988; Rosen and Schwalbe, 1995), basically consist of hand capture, spearing with a frog "gig" (as in sport hunting), and trapping using turtle traps (hoop nets) set at the ends of seine leaders. The traps consisted of 4-6' deep, 10-20' long seines attached to metal stakes, with 6-12" of net above water line; hoop nets were attached to the stakes with approximately 3/8 of the funnel out of the water. Seines generally had 1/4 - 1/2" mesh, traps had 1" mesh. Pre-made fyke nets, similar in principle to our design, were used in Robertson Ciénega. The 1" (2.5 cm) mesh of the frog traps begins to capture bullfrogs as they reach about 90 mm snout-vent length (SVL) and about 90 g total mass.

Removals initially focused on North Pond, and secondarily at Black Draw and House Pond (Tables 1-4). North Pond received consistent removal efforts during each visit. Removals 2-3 times per year failed to control bullfrog populations. Between the Memorial Day (last week of May) and Labor Day (first week of September) removals, and from Labor Day to the following Memorial Day, bullfrog populations generally rebounded to 50-100% or more of their original numbers. There was no downward trend in bullfrog numbers over the Phase I years in any of the ponds, except that bullfrogs became scarce in Twin Pond (Tables 1-4), which was temporarily dried. Although persistent decrease in bullfrog abundance was not achieved, reductions undoubtedly maintained lowered abundance for some part of the year. North Pond usually contained an estimated 5-10 remaining adult frogs after removal of 50 or more, so about 80-90% reduction had been achieved in 3-4 d of work.

Bullfrog removal was re-initiated in 1992, and intensified during 1993-5, with the longest trapping period and most extensive manual removal occurring in 1994 and 1995 (Table 5). Table 5 is the best available index of removal effort, which varied from year to year due to fluctuations in weather and the number of skilled frog collectors during the manual removal efforts. In 1985 and in May 1986, bullfrog removal was incidental to the initial garter snake survey. Intensive removal began in August 1986 at North and Twin Ponds, with seven workers present. All subsequent trips included large enough numbers of frog catchers to effectively cover the major bullfrog population centers on the refuge. Thus, for 1987-1995, days of manual removal is approximately equal to total manual removal effort. This is reflected in the total numbers and mass of frogs removed from the refuge (Tables 1-4, Fig. 1).

**Bullfrog Population Trends at SBNWR.** Annual variation in mass of large (subadult + adult) bullfrogs removed (Table 4) roughly reflects total removal effort. At each of the four sites where intensive removals had been ongoing since 1992, 1994 saw a decline in biomass removed (Fig. 1). In 1995, there was a slight increase in removal effort (Table 5A&B). Among the intensively worked ponds, there was only a slight decline in the mass and number of bullfrogs removed from House, North, and Tule ponds, and an increase in the mass and number removed from Twin Pond (Fig. 1; Tables 1 and 2). This suggests that the control methods, as currently applied, have reached a point at which further reductions in the bullfrog population may not be dramatic. Alternate or additional approaches appear to be required if control is to be achieved.

Similarly, average size of the bullfrogs in at least three of these four sites also declined in 1994, but did not decline further overall in 1995 (Fig. 2). Again, the method apparently resulted in a fairly thorough removal of adults, but failed to control reproductive rebound of the frog population. It is apparent that a tremendous harvest pressure can be withstood by a healthy bullfrog metapopulation such as this one. Overall, the results indicate that a re-evaluation of the removal approach is needed. Modifications of, and additions to, the approach are needed, or an alternate approach may be called for.

The great numbers of bullfrogs taken in 1994 at Mesquite Pond, plus those from Robertson Ciénega, Double Phd Ponds, Oasis Pond, and Bathhouse Spring (all first intensively sampled in 1993 or 1994) account for the increase in total numbers of frogs removed that appears in Tables 1-4. The increase in total frogs in 1995 (Table 1) is primarily a result of attempts to remove significant numbers of small juvenile bullfrogs, particularly at Twin Pond. The

numbers of larger bullfrogs removed in 1995 was similar to the number in 1994 (Table 2).

The decline in biomass removal at certain sites (North Pond, House Pond) reflects both reduced numbers of frogs and declining size of the larger frogs (Tables 6, 7, Fig. 2). This decline occurred because most adult frogs were being removed, as described above, including at House Pond, where trapping was not carried out, but which was the 1994 and 1995 focal point for manual removal efforts. Results at House Pond also may reflect the effects of cattail removal (via poisoning by the Johnson Historical Museum) on vulnerability of bullfrogs to our manual removal methods.

In newly-trapped areas, we have generally observed 1-6 weeks of highly successful trapping of large adult frogs, with variability depending on habitat complexity and trap density. This has been followed by slow attrition of the remaining large adults and steady, continual removal of young as they reach trappable size (Fig. 3). Results in 1996 will indicate whether this procedure succeeds in any further restriction of bullfrog reproduction or recruitment.

During 1994, we removed 26 bullfrog egg masses from Mesquite Pond, and observed approximately 6 that had already hatched, May 28-31; approximately 20-30 egg masses were also removed from House Pond May 29-30, although this was a less systematic effort. Approximately 15 egg masses were removed from House Pond in May 1995. These efforts were not systematic enough to contribute substantially to control efforts.

**Discussion of Possible Modifications of Existing Bullfrog Removal Methodology.** Additional removal techniques should be employed. Regular and systematic survey for and removal of bullfrog egg masses should be conducted in most or all refuge areas starting April 15 (or earlier, depending on when choruses of calling males are first heard), and continuing to June 15. These should be at least once a week until May 1, and twice weekly thereafter.

Bullfrog trapping should be initiated by mid-April, to enable traps to remove a substantial fraction of adult frogs prior to the onset of egg-laying. Further, a manual removal effort should be mounted in early-mid May, with the same goal. It is critical to initiate bullfrog removals prior to initiation of spring breeding. If these modifications do not have the desired effect, alternative methods will be required, and the removal approach will be judged to have been unsuccessful at SBNWR.

The large number of frogs removed at the beginning of removal operations each year (Fig. 3) also suggests a need to begin trapping earlier and continue later each year. Alternatively, Fig. 3 may imply a need to move the traps around periodically.

Additionally, we propose that experiments be conducted on Buenos Aires National Wildlife Refuge or nearby in Coronado National Forest (at Alamito Tank) to test effectiveness of underwater explosion in elimination of bullfrogs and other non-indigenous vertebrates from stock ponds. This procedure should be supervised and implemented by personnel from both refuges, with site plans and timing developed in consultation with us, and the work should be observed and biological effects evaluated by us.

## LEOPARD FROGS

### Management, Monitoring, and Natural History, 1995.

*A. Magoffin Ranch and Vicinity.* On 25 Feb 1995, Matt Magoffin counted 25 Chiricahua leopard frogs at Belency tank, plus 2 egg masses (1 fresh, 1 older, *plus* one that he observed the previous fall there). On the same date, he saw 2 adults at Rosewood, with one fresh egg mass (by Mar 5, these eggs were near hatching, and only 8-10 individual eggs were not developing, all on a top corner of the mass). The first leopard frogs had been observed on 18 Feb 1995 (and bullfrogs were calling on Feb 21 at Robertson Ciénega).

In mid-April, Matt Magoffin observed one more egg mass each in Belency and Rosewood Tanks. In early May, he counted 8-12 leopard frogs in Belency Tank and 4-5 in Rosewood Tank, but had observed no tadpoles. On 29 May 1995, we observed 9 adult Chiricahua leopard frogs at Belency Tank (1630-1730 hr), and Matt Magoffin reported that he had usually observed 12 individuals at the site over the past two weeks. He observed a total of 6 egg masses at Belency during Spring 1995, although we were not able to capture any tadpoles by seine on May 29. At Rosewood Tank, Matt Magoffin reported that during late May he had usually observed 4 large adult leopard frogs (two egg masses, one of which clearly hatched successfully, plus a third the previous fall), although on May 29 we were unable to see frogs or dipnet tadpoles.

On 23 July 1995, Shawn Sartorius observed 1 large Chiricahua leopard frog and caught a small leopard frog tadpole in a single dipnet sweep at Rosewood Tank, 1543-1626 hr.

During August 1995, Matt Magoffin observed approximately 12 leopard frogs at Belency Tank, including several juveniles that transformed during summer 1995. Rainfall filled the renovated sediment trap at Belency in August, and created pools in the extensive sacaton bottom in which the tank resides, so the frogs were probably dispersed and not countable at this season. At Rosewood Tank, which has not filled and has thus been supplied with water only directly by the Magoffins, Matt Magoffin reported generally observing 3 large frogs, and approximately 40 tadpoles during August 1995. These tadpoles were stunted, presumably as a result of crowding in the 2 x 3 m x 1-1.5 m deep pool maintained at Rosewood, and they disappeared as fast as they transformed. It appeared likely that they would be vulnerable to predation by the adult frogs under the existing circumstances. A total of 47 such tadpoles found their way to Choate Tank, during August (a total of 66 by early September) where the Magoffins refurbished a windmill-powered well and created a small pond.

On 1 September 1995, Matt Magoffin observed 4 adult leopard frogs at Rosewood Tank, although we observed none on September 2, 1420-1430 hr. On September 3 we observed 3 huge adults at Rosewood Tank (2005-2055 hr), and removed a large female checkered garter snake. Dipnetting efforts yielded 19 Chiricahua leopard frog tadpoles which were 10-17 mm body length but had small hind legs. Apparently, our May dipnetting efforts were unsuccessful because the tadpoles were too small and/or too wary. A large number must have been present at that time at Rosewood Tank.

At Choate we observed 3 Chiricahua leopard frogs on 3 Sep 1995, 2130-2205 hr (2 metamorphs plus one metamorphosing tadpole). At Belency Tank on the same night, 2230-2310

hr, we observed 15 adult leopard frogs of various sizes, but others may have been unobserved in the glaring moonlight. One male was observed with inflated vocal sacs, indicating that breeding was occurring at that time. Herons subsequently descended upon Belency Tank for some weeks in late summer and early fall. No frogs were observed there during winter 1995-6. At Choate, 25-30 juvenile frogs were observed during fall 1995.

Guadalupe Canyon was visited and all sites checked 1-3 times by us during 1995. No frogs were observed. Centrarchid fishes (largemouth bass, and/or bluegill sunfish) had made their way into the lower pond adjoining the original pond at Hadley's ranch, presumably precluding the functioning of that site as a drought refuge for the leopard frogs. This population, and the entire Peloncillo population of Chiricahua leopard frogs, may be extirpated.

*B. Leslie Creek at Leslie Canyon National Wildlife Refuge.* On 30 May 1995, Shawn Sartorius observed just a single Chiricahua leopard frog along Leslie Creek, 1249-1627 hr. The following day, two tiger salamander larvae (*Ambystoma tigrinum*) were observed in the pool above the upper rock dam on Leslie Creek in Leslie Canyon. Dipnetting in the 200 m of stream below this dam on 25 Jun 1995, yielded an abundance of leopard frog tadpoles in two size classes, neither with legs and both apparently from winter-spring egg masses. On the same date, dipnetting downstream, at and below the old gaging station yielded two larger tadpoles with well-developed legs, presumably from fall egg masses. A single adult Chiricahua leopard frog was observed. Subsequently, extensive illegal immigration or smuggling activity at Leslie Canyon during summer 1995 dampened survey activities.

On 20 Aug 1995, Shawn Sartorius observed 2 adult and 3 juvenile Chiricahua leopard frogs near the upper, main dam in Leslie Canyon. On August 21, a thorough search of the creek, 1415-1645 hr, revealed 24 leopard frogs (19 juveniles, 1 metamorph, 4 large tadpoles) distributed throughout the area from the upper dam to the lower reach (at the main road-crossing [bridge]). At this time, there was high water, and more frogs were probably overlooked than expected for low or normal flow. On August 23, 1815-1915 hr, 8 leopard frogs were observed at and below the main rock dam.

In general during 1995, following the 1994 drought, leopard frogs were in low abundance at Leslie Canyon, compared to the 20 or more adults observable in 1994 and the hundreds visible in the mid-1980's (Rosen and Schwalbe, 1988). Nonetheless, the presence of tadpoles of varying sizes in 1995 indicates consistent and successful reproduction by Chiricahua leopard frogs in Leslie Canyon.

*C. Observations at the SBNWR Enclosure.* Careful observation at the enclosure by Cobble, Magoffin, and Rosen yielded counts of 3-29 leopard frogs, usually 12-26, during summer and fall of 1995 (Table 9), approximately three times the values obtained during 1994 (the first year leopard frogs were in this enclosure). Dense vegetation ensures that these values underestimate the actual number of frogs. The counts were generally consistent, after accounting for such factors as temperature, visibility, and effort, and suggest that perhaps 50-100 or more frogs may have been present.

We observed 29 *R. chiricahuensis* participating in calling or breeding activity in the enclosure on 1 Sep 1995. For the first time in 1995, two large adult Chiricahua leopard frogs were

observed, apparently 2 year old survivors from the transforming cohort introduced in late spring 1994. These individuals, and probably more of their cohort, had gone unobserved during all of 1995 to this point. These observations also suggest that the leopard frog population in the enclosure had tripled from 1994, when 6-10 individuals were counted during a September 2 breeding chorus.

Despite the installation of hardware cloth eaves atop the enclosure fence in winter 1994-5, four juvenile bullfrogs were removed from the leopard frog enclosure during spring and summer 1995, and at least two new ones were observed in September 1995. These numbers are far below those in 1994, prior to installation of the eaves, but they nonetheless suggest that the entire fence should be lined on the outside with aluminum flashing to further reduce bullfrog entry.

### Garter Snakes

We have made 36 recaptures of marked Mexican garter snakes, *Thamnophis eques*, and 105 of checkered garter snakes, *T. marcianus*, among 498 garter snake capture records through 1995 (Table 9). Our extensive efforts in 1995 resulted in a doubling of the total captures for garter snakes, with the greater part of the increase being for the checkered garter snake. The relative frequency of *T. eques* to *T. marcianus* continued to fall, as noted previously. This trend is probably a response to selectively heavy bullfrog predation on the more aquatic Mexican garter snake.

Recapture data indicate that adult *T. eques* are long-lived, with known ages of 6, 7, 7, and 10 yr confirmed by long-term recaptures of individuals marked as juveniles or young adults in the 1980's on the refuge. Our data for *T. marcianus* suggest lower survivorship is likely, as expected for garter snakes. However, observed growth rates for *T. marcianus* at SBNWR have been low, and the size distribution suggests there may be a number of older individuals present. Our recapture data show that *T. marcianus* is capable of very rapid healing, a fact also reflected in bizarre observations of severely wounded snakes found fully healed and apparently healthy. Because of this healing ability, our results for this species must be interpreted conservatively. We are moving to PIT (passively induced transponder) tagging for this species.

The Mexican garter snake has persisted on the refuge most likely because high adult survivorship slows the decline of a decreasing species. As such, it appears to be in a continuing decline. In 1995 we observed 17 individuals, of which only 1 neonate and 9 other, larger snakes had not been previously marked. Previously, 64 individual Mexican garter snakes had been marked on the refuge over the preceding decade, and many of them have certainly died since marking. It is therefore clear that we estimate fewer than 146 individuals in the study population--in fact far fewer. A preliminary estimate suggests that there were less than 50 individuals remaining in the refuge population during 1995.

The 1995 sample of Mexican garter snakes at SBNWR contained one neonate, no yearlings, and several individuals born in 1993 or 1992. These individuals confirm an early success of bullfrog removal efforts (Rosen and Schwalbe, 1996), but indicate that subsequent to 1993, bullfrog removals have been less effective in terms of Mexican garter snake recruitment. This is also consistent with the failure of 1995 bullfrog removal data to show a continuing decline, and suggests that early spring trapping, as in 1993, may be significantly better than the delayed

onset of full trapping effort, as in 1994 and 1995. During 1993 and early 1994, it was evident that a very strong reduction of the bullfrog population at Twin Pond and Evil Twin had been accomplished. Whether this was possible because that population was just recovering from the previous pond drying episode, or, more likely, because of a timely onset of trapping, it appears to be this successful removal that led to successful recruitment of Mexican garter snakes described by Rosen and Schwalbe (1996).

In 1995, we observed Mexican garter snakes at North Pond, including a gravid female, indicating that our speculation about the demise of this deme (Rosen and Schwalbe, 1996) was premature. We also recorded a number of male Mexican garter snakes at Robertson Ciénega and Twin Pond, indicating that reproduction remains possible. As previously, we found this species in Twin, Evil Twin, Robertson, and Mesquite Ponds, but none of the other sites. They are probably absent from all other sites except Oasis Pond. We have not seen this species in Black Draw during the 1990's.

The gravid female *T. eques* from North Pond had a severely infected tail as a result of repeated bullfrog bites. It was held in the laboratory from May 29 to June 26, when she died after giving birth June 20 to an unusually small litter of sickly young. Another female from North Pond with this tail condition was held captive in 1994, and despite avid feeding, like the gravid one, became lethargic and died after a feeding hiatus of only 5 days. The litter consisted of 11 completely undeveloped eggs, 10 severely stunted young, 8 of which were stillborn or died shortly, and eight small but healthy young. Seven of the nine survivors are alive under captive care as of 25 Jul 1996.

In 1995, we obtained the first record of predation by a bullfrog on a Mexican garter snake at SBNWR: a neonate in the stomach of a subadult bullfrog (117 mm SVL, 108 g mass) from Robertson Ciénega.

The refuge population of *T. eques* was probably a Black Draw population originally. When the central draw spring dried in about 1990, recruiting young emigrated, and several have subsequently been captured at North and Twin Ponds. No other recaptured individuals have departed from the pond where they were marked (although some moved between Twin and Evil Twin ponds). Robertson Ciénega was probably heavily colonized by Mexican garter snakes emigrating in numbers from Black Draw during the late 1980's and early 1990's. Similarly, some emigrants from the draw probably colonized Mesquite and Oasis ponds, but these areas were long-standing artesian-fed ciénegas (with leopard frogs in the early 1980's) that had moderate bullfrog populations prior to the construction of Mesquite and Oasis ponds in 1990-1991. We observed young Mexican garter snakes in the tules at this site in 1985-6, although they were not caught. Thus, this subpopulation on the refuge, which we have never trapped extensively, predates the one at Robertson. It is also in steep decline: we have seen and heard of only extremely large females (five records) from Mesquite and Oasis ponds.

To summarize, recruitment of Mexican garter snakes on the refuge occurred during the late 1980's in central Black Draw, in 1993 at Twin Pond, and possibly some time during the early 1990's at Robertson Ciénega prior to saturation of that site by bullfrogs. At present, the population continues to decline, and may comprise less than 50 individuals, plus the seven captives. The situation for this species in Cochise County is critical. Although it may still occur in a small

population at and near Lewis Springs (last verified in 1986 [Rosen and Schwalbe, 1988]), the refuge population seems to be headed for extinction, barring additional and successful management efforts.

## RECOMMENDATIONS

1. Continue intensive bullfrog removals at SBNWR via manual capture and continuous trapping for another two years to track results:

    A. Trapping should be initiated during the 1st week of April, and continued to at least mid-October.

    B. Manual removals should occur first in early May.

2. Utilize additional methods of bullfrog control at SBNWR, especially egg mass removal.

3. Evaluate effectiveness of doubling the density of bullfrog traps, starting with North Pond.

4. Evaluate effectiveness of moving traps around during a trapping season by moving half of all traps in early August 1996, and comparing capture rates in moved versus un-moved traps.

5. Develop plans to utilize drift fence encirclement of ponds, with drying of the encircled pond that may be undertaken as part of native fish management:

    A. One pond should be encircled in 1996 regardless of plans for drying of ponds.

    B. Ponds that are to be dried for native fish management should be first encircled with drift fence to capture and remove all bullfrogs (in pitfall and funnel traps along the inside of the fence), which would otherwise emigrate to other ponds during drying. The fence should then be left in place to minimize recolonization by bullfrogs, and to allow restocking with Chiricahua leopard frogs and Mexican garter snakes. Further details should be worked out in conjunction with refuge personnel.

6. A full aquatic survey of the Mexican portion of the original San Bernardino land grant lowlands is needed at this time, prior to cost-intensive pond drying operations. An inventory of occurrence and general abundance of aquatic herpetofauna is required, as well as data on fishes.

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Arizona Game and Fish Department has also been instrumental in all phases of the work. The project began as the offspring of Rosen's (then an AGFD contract biologist) and Schwalbe's (then AGFD State Herpetologist) survey work on garter snakes, and was initiated and sustained only by the early participation of many AGFD personnel. Since that time, Jeff Howland (AGFD Amphibian and Reptile Program Manager) has assumed a key role in organizing the continuing strong participation by AGFD personnel, and he, Mike Sredl, and their staff have brought added biological expertise to the project. The funding support of the AGFD Heritage Grants Program and participation of AGFD Nongame Branch personnel have been instrumental in the development of the broad scope and larger undertakings of the project.

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## Literature Cited

Hayes, M.P. and M.R. Jennings. 1986. Decline of ranid frog species in western North America: are bullfrogs (*Rana catesbeiana*) responsible? J. Herpetol. 20:490-509.

Rosen, P.C. and C. R. Schwalbe. 1988. Status of the Mexican and narrow-headed gartersnake

(*Thamnophis eques megalops* and *Thamnophis rufipunctatus rufipunctatus*) in Arizona. Unpubl. report from Arizona Game and Fish Dept. (Phoenix, Arizona) to U.S. Fish and Wildlife Service, Albuquerque, New Mexico.

Rosen, P.C. and C.R. Schwalbe. 1995. Bullfrogs: introduced predators in southwestern wetlands. Pp. 542-454 *in* Laroe, E.T., G.S. Farris, C.E. Puckett, P.D. Doran, and M.J. Mac (*eds.*), Our Living Resources: A Report on the Distribution, Abundance, and Health of U.S. Plants, Animals, and Ecosystems. U.S. Dept. of Interior, National Biological Service, Washington, D.C. 530 pp.

Rosen, P.C. and C.R. Schwalbe. 1996. Bullfrog Impacts on Sensitive Wetland Herpetofauna, and Herpetology of the San Bernardino National Wildlife Refuge. Final Report to Arizona Game and Fish Department Heritage Fund and U.S. Fish and Wildlife Service. 47 pp.

Schwalbe, C.R. and P.C. Rosen. 1988. Preliminary report on effects of bullfrogs on wetland herpetofauna in southeastern in Arizona. Pp. 166-173 *in* R.C. Szaro, K.E. Severson, and D.R. Patton (editors), Management of Amphibians, Reptiles, and Small Mammals in North America. U.S. Forest Service, General Technical Report RM-166, Fort Collins, CO.

Table 1. Number of *Rana catesbeiana* removed from San Bernardino NWR, Cochise Co., Arizona.

| | YEAR | | | | | | | | | Site |
|---|---|---|---|---|---|---|---|---|---|---|
| LOCALITY | 85 | 86 | 87 | 88 | 89 | 92 | 93 | 94 | 95 | Total |
| Astin Spring | 0 | 0 | 0 | 0 | 0 | 0 | 30 | 4 | 14 | 48 |
| Bathhouse Well | 0 | 0 | 2 | 0 | 0 | 0 | 7 | 15 | 11 | 35 |
| Cottonwood Well | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Black Draw | 0 | 0 | 71 | 102 | 45 | 11 | 0 | 0 | 93 | 322 |
| Evil Twin | 0 | 0 | 0 | 0 | 0 | 0 | 27 | 5 | 17 | 49 |
| House Pond | 0 | 0 | 110 | 73 | 175 | 143 | 189 | 234 | 269 | 1193 |
| Mesquite Pond | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 261 | 186 | 447 |
| North Pond | 0 | 85 | 139 | 168 | 290 | 140 | 146 | 247 | 181 | 1396 |
| Oasis Pond | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 35 | 44 |
| Double PhD | 0 | 0 | 0 | 4 | 0 | 0 | 1 | 6 | 30 | 41 |
| Robertson Cienega | 0 | 0 | 0 | 0 | 0 | 16 | 72 | 78 | 132 | 298 |
| Tule Pond | 0 | 1 | 6 | 2 | 0 | 1 | 19 | 15 | 23 | 67 |
| Twin Pond | 4 | 5 | 0 | 3 | 0 | 43 | 111 | 114 | 491 | 771 |
| ANNUAL TOTAL | 4 | 93 | 328 | 352 | 510 | 354 | 602 | 988 | 1482 | 4713 |

Table 2. Number of adult and subadult *Rana catesbeiana* (≥ 90 mm SVL) removed from San Bernardino NWR, Cochise Co., Arizona.

| | YEAR | | | | | | | | | Site |
|---|---|---|---|---|---|---|---|---|---|---|
| LOCALITY | 85 | 86 | 87 | 88 | 89 | 92 | 93 | 94 | 95 | Total |
| Astin Spring | 0 | 0 | 0 | 0 | 0 | 0 | 26 | 3 | 4 | 33 |
| Bathhouse Well | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 15 | 11 | 32 |
| Cottonwood Well | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Black Draw | 0 | 0 | 64 | 102 | 45 | 11 | 0 | 0 | 0 | 222 |
| Evil Twin | 0 | 0 | 0 | 0 | 0 | 0 | 27 | 5 | 16 | 48 |
| House Pond | 0 | 0 | 106 | 53 | 145 | 113 | 186 | 162 | 201 | 966 |
| Mesquite Pond | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 252 | 185 | 437 |
| North Pond | 0 | 80 | 124 | 121 | 208 | 135 | 141 | 215 | 156 | 1180 |
| Oasis Pond | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 | 35 | 44 |
| Double PhD | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 6 | 28 | 36 |
| Robertson Cienega | 0 | 0 | 0 | 0 | 0 | 15 | 72 | 76 | 114 | 277 |
| Tule Pond | 0 | 1 | 5 | 1 | 0 | 1 | 19 | 15 | 23 | 65 |
| Twin Pond | 4 | 5 | 0 | 2 | 0 | 39 | 108 | 107 | 135 | 400 |
| ANNUAL TOTAL | 4 | 88 | 299 | 281 | 398 | 314 | 585 | 865 | 908 | 3742 |

Table 3. Total mass of *Rana catesbeiana* removed (kg) from San Bernardino NWR, Cochise Co., Arizona.

| LOCALITY | YEAR 85 | 86 | 87 | 88 | 89 | 92 | 93 | 94 | 95 | Site Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Astin Spring | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4.4 | 0.5 | 1.3 | 6.2 |
| Bathhouse Well | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.2 | 3.0 | 1.6 | 5.9 |
| Cottonwood Well | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 |
| Black Draw | 0.0 | 0.0 | 15.4 | 19.7 | 7.5 | 2.3 | 0.0 | 0.0 | 0.7 | 45.7 |
| Evil Twin | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5.2 | 1.0 | 3.2 | 9.5 |
| House Pond | 0.0 | 0.0 | 26.1 | 13.2 | 37.8 | 47.1 | 79.7 | 64.3 | 63.9 | 332.1 |
| Mesquite Pond | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 59.3 | 38.8 | 98.1 |
| North Pond | 0.0 | 18.5 | 30.3 | 28.3 | 45.8 | 36.4 | 31.9 | 29.0 | 28.0 | 248.0 |
| Oasis Pond | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.6 | 6.1 | 7.7 |
| Double PhD | 0.0 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.1 | 1.4 | 6.0 | 8.0 |
| Robertson Cienega | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.4 | 13.4 | 15.9 | 22.4 | 55.1 |
| Tule Pond | 0.0 | 0.2 | 1.2 | 0.3 | 0.0 | 0.2 | 5.1 | 2.4 | 4.5 | 13.9 |
| Twin Pond | 0.8 | 1.4 | 0.0 | 0.4 | 0.0 | 9.6 | 24.6 | 16.4 | 33.6 | 86.8 |
| ANNUAL TOTAL | 0.8 | 20.4 | 73.0 | 62.4 | 91.1 | 98.9 | 165.7 | 194.8 | 210.1 | 917.3 |

Table 4. Kilograms of large *Rana catesbeiana* (≥ 90 mm SVL) removed, San Bernardino NWR, Cochise Co., AZ.

| LOCALITY | YEAR 85 | 86 | 87 | 88 | 89 | 92 | 93 | 94 | 95 | Site Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Astin Spring | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4.2 | 0.5 | 1.0 | 5.6 |
| Bathhouse Well | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.2 | 3.0 | 1.6 | 5.9 |
| Cottonwood Well | 0.0 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 |
| Black Draw | 0.0 | 0.0 | 15.2 | 19.7 | 7.5 | 2.3 | 0.0 | 0.0 | 0.0 | 44.7 |
| Evil Twin | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 5.2 | 1.0 | 3.1 | 9.4 |
| House Pond | 0.0 | 0.0 | 25.9 | 12.5 | 36.9 | 46.5 | 79.6 | 62.0 | 61.5 | 325.0 |
| Mesquite Pond | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 59.1 | 38.8 | 97.9 |
| North Pond | 0.0 | 18.3 | 29.5 | 26.3 | 43.4 | 36.2 | 31.7 | 27.8 | 27.3 | 240.3 |
| Oasis Pond | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.6 | 6.1 | 7.7 |
| Double PhD | 0.0 | 0.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.0 | 1.4 | 5.9 | 7.8 |
| Robertson Cienega | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 3.3 | 13.4 | 15.8 | 22.0 | 54.6 |
| Tule Pond | 0.0 | 0.2 | 1.2 | 0.2 | 0.0 | 0.2 | 5.1 | 2.4 | 4.5 | 13.8 |
| Twin Pond | 0.8 | 1.4 | 0.0 | 0.4 | 0.0 | 9.5 | 24.5 | 16.3 | 30.6 | 83.5 |
| ANNUAL TOTAL | 0.8 | 20.3 | 71.8 | 59.6 | 87.9 | 98.0 | 165.0 | 190.9 | 202.5 | 896.7 |

Table 5A. Manual bullfrog removal work (effort) at San Bernardino National Wildlife Refuge, Cochise Co., Arizona, 1985-1995. Removal trips were Memorial and Labor day weekends, beginning with Labor Day in 1986. An additional intensive manual removal was conducted on Independence Day weekend, 1988.

| Year | Days Intensive Manual Removal | Ave. Number of Personnel/Trip |
|---|---|---|
| 1985 | 0 | 2 |
| 1986 | 2 | 7 |
| 1987 | 6 | 10 |
| 1988 | 10 | 10 |
| 1989 | 7 | 11 |
| 1990 | 0 | 0 |
| 1991 | 0 | 0 |
| 1992 | 7 | 18 |
| 1993 | 6 | 15 |
| 1994 | 7 | 16 |
| 1995 | 6 | 25 |

Table 5B. Trapping effort for bullfrogs (Rana catesbeiana) at San Bernardino National Wildlife Refuge, Cochise Co., Arizona. The number of trap days is followed by (number of traps set).

| | YEAR | | | | | | | | | Site |
|---|---|---|---|---|---|---|---|---|---|---|
| LOCALITY | 85 | 86 | 87 | 88 | 89 | 92 | 93 | 94 | 95 | Total |
| Astin Spring | | | | | | | | | | |
| Bathhouse Well | | | | | | | 67 (1) | 224 (1) | 153 (1) | 444 |
| Cottonwood Well | | | | | | | | | | |
| Black Draw | | | | 30 (10) | 54 (9) | 44 (11) | | 120 (4) | | 248 |
| Evil Twin | | | | | | | 270 (3) | 224 (1) | 298 (2) | 792 |
| House Pond | | | | | | | | | | |
| Mesquite Pond | | | | | | | | 674 (5) | 918 (6) | 1592 |
| North Pond | 2 (1) | | | 6 (2) | 6 (1) | | 627 (4) | 896 (4) | 745 (5) | 2282 |
| Oasis Pond | | | | | | | | 76 (1) | 298 (2) | 374 |
| Double PhD | | | | | | | | 118 (1) | 270 (2) | 388 |
| Robertson Cienega | | | | | | | 264 (2) | 278 (2) | 149 (1) | 691 |
| Tule Pond | | | | | | | 134 (2) | 374 (2) | 306 (2) | 814 |
| Twin Pond | 2 (1) | | | | | | 552 (5) | 832 (4) | 596 (4) | 1982 |
| ANNUAL TOTAL | 4 (2) | 0 (0) | 0 (0) | 36 (12) | 60 (10) | 44 (11) | 1914 (17) | 3816 (25) | 3733 (26) | 9607 |

Table 6. Mean SVL of adult and subadult bullfrogs (≥ 90 mm SVL) captured at SBNWR, Arizona, 1985-1995.

| Locality | YEAR 85 | 86 | 87 | 88 | 89 | 92 | 93 | 94 | 95 | site average |
|---|---|---|---|---|---|---|---|---|---|---|
| Astin Spring | | | | | | | 118.2 | 120.3 | | 118.4 |
| Bathhouse Well | | | | | | | 124.0 | 128.8 | 120.7 | 125.6 |
| Black Draw | | | 135.4 | 131.0 | 124.1 | 129.4 | | | | 130.8 |
| House Pond | | | 132.0 | 136.1 | 140.5 | 168.1 | 164.5 | 164.3 | 151.0 | 153.4 |
| Mesquite Pond | | | | | | | | 146.5 | 146.3 | 146.4 |
| North Pond | | 130.5 | 133.1 | 132.0 | 134.3 | 148.4 | 139.1 | 112.3 | 125.3 | 133.0 |
| Robertson Marsh | | | | | | 142.4 | 133.6 | 135.2 | 134.8 | 135.1 |
| Tule Pond | | 116.0 | 137.0 | 134.0 | | 149.0 | | 134.3 | 126.4 | 131.1 |
| Twin Pond | 135.0 | 133.6 | | 133.5 | | 145.4 | 141.4 | 126.5 | 140.0 | 138.9 |
| ANNAUL MEAN | 135.0 | 130.7 | 133.2 | 132.3 | 135.4 | 154.2 | 147.9 | 142.8 | 140.7 | 141.0 |

Table 7. Mean mass of adult and subadult bullfrogs (≥ 90 mm SVL) captured, SBNWR, Arizona, 1985-1995.

| Locality | YEAR 85 | 86 | 87 | 88 | 89 | 92 | 93 | 94 | 95 | Site average |
|---|---|---|---|---|---|---|---|---|---|---|
| Astin Spring | | | | | | | 161.5 | 154.7 | 245.0 | 171.0 |
| Bathhouse Well | | | | | | | 200.3 | 202.6 | 147.1 | 183.1 |
| Black Draw | | | 237.2 | 193.1 | 167.4 | 204.6 | | | | 201.2 |
| House Pond | | | 244.4 | 236.3 | 254.8 | 411.7 | 428.0 | 382.6 | 306.0 | 336.5 |
| Mesquite Pond | | | | | | | | 234.6 | 209.5 | 224.0 |
| North Pond | | 228.2 | 237.6 | 217.3 | 208.6 | 268.3 | 224.6 | 129.2 | 174.9 | 203.7 |
| Robertson Marsh | | | | | | 222.4 | 186.7 | 208.0 | 193.2 | 197.1 |
| Tule Pond | | 180.0 | 241.2 | 207.0 | | 219.0 | 270.3 | 160.1 | 194.8 | 212.8 |
| Twin Pond | 200.0 | 283.2 | | 198.5 | | 242.9 | 220.0 | 154.8 | 223.6 | 207.3 |
| ANNUAL TOTAL | 200.0 | 230.1 | 240.0 | 212.2 | 220.8 | 312.2 | 282.0 | 220.7 | 223.0 | 239.6 |

Table 8. Monitoring results for Chiricahua leopard frogs in enclosure, SBNWR, Arizona, 1994 and 1995.

| Date | Time | Observer | No. leopard frogs | Method; Annotations |
|---|---|---|---|---|
| 1994: | | | | |
| 31-May | 0843 - 0943 | Rosen | 18 | Binoculars. (all metamorphs) |
| 15-Jun | 1025 - 1035 | Rosen | 8 | Splash count |
| 17-Jun | 1000 - 1100 | Rosen | 9 | Binoculars; 1 green heron |
| 18-Jun | 0830 - 0840 | Rosen | 3 | Splash count; 1 green heron |
| 6-Jul | 0840 - 0910 | Rosen | 4 | Binoculars + Splash Count; 2 green herons |
| 7-Jul | 1203 - 1216 | Rosen | 2 | Splash count; 1 green + 2 great blue herons |
| 7-Jul | 2230 - 2330 | Rosen | 15 | Head lamp. (11 juvenile, 3 metamorph, 1 tadpole) |
| 8-Jul | 0934 - 0954 | Rosen | 6 | Splash count |
| 19-Jul | 1847 - 1909 | Rosen | 12 | Splash count; just after sunset |
| 15-Aug | 1030-1100 | Cobble | 9 | Binocs. 6 juv bullfrogs seen |
| 17-Aug | 1030-1055 | Cobble | 10 | Binocs. 4 juv bullfrogs seen |
| 18-Aug | 1100-1130 | Cobble | 13 | Binocs. 4 juv bullfrogs seen |
| 2-Sep | 2305 - 2335 | Rosen | 7 | Head lamp; males calling; 2 juvenile bullfrogs shot |
| 6-Sep | 1740 - 1804 | Rosen | 7 | Binoculars; 3 juvenile bullfrogs seen |
| 6-Sep | 1530 - 1550 | Cobble | 4 | Binocs; 1 checkered garter, 11 juv bullfrogs seen |
| 6-Sep | 2103 - 2309 | Rosen | 7 | Head lamp; garter sn removed, 13 bullfrogs shot |
| 9-Sep | 1040 - 1055 | Rosen | 4 | Splash count |
| 12-Sep | 1530 - 1550 | Cobble | 2 | Binoculars; 2 juvenile bullfrogs seen |
| 16-Sep | 1510 - 1525 | Cobble | 7 | Binoculars; 4 juvenile bullfrogs seen |
| 28-Sep | 0800 - 0900 | Cobble | 7 | Binoculars; 9 juvenile bullfrogs shot |
| 28-Sep | 1500 - 1600 | Cobble | several | Binoculars; 9 juvenile bullfrogs shot |
| 29-Sep | NA | Cobble | NA | 1 checkered garter snake seen |
| 5-Oct | 1400 - 1500 | Cobble | 8 | Binoculars; 3 juvenile bullfrogs seen |
| 11-Oct | 1445 - 1505 | Cobble | 1 | Binoculars, 3 juvenile bullfrogs seen |
| 1995: | | | | |
| 3-Mar | a.m. | Cobble | 14 | Binocs. 1 adult, 13 juveniles |
| 10-Apr | 1600-1620 | Cobble | 12 | Binocs. 2 ad,10 juv, + 1 metamorph bullfrog |
| 27-May | 1530-1630 | Rosen | five | Dipnetting tadpoles (all large |
| 27-May | 2030-2130 | Rosen | 4 | Head lamp. Removed one 7-8 cm bullfrog |
| 28-May | night | Rosen | 0 | Head lamp. 3 7-8 cm bullfrogs seen, 1 shot. Air cold |
| 31-May | night | Sartorius | n/a | 1 bullfrog shot |
| 7-Jun | 0630-0700 | Magoffin | 28 | Binoculars |
| 8-Jun | ? | Cobble | 3 | Binocs. 1 juvenile garter snake seen |
| 13-Jun | ? | Magoffin | 26 | Binocs. All juv., + 2 bullfrogs |
| 15-Jun | ? | Cobble | 18 | Binoculars. All juveniles |
| 21-Jun | 2205-2330 | Rosen | 15 | Head lamp. All juv. 1 lg juv. bullfrog shot |
| 23-Jun | 0900-0920 | Rosen | 3 | Splash count. Dipnetting yielded 1 pre-metamorph |
| 9-Aug | 1015-1030 | Cobble | 8 | Binocs. All juv. Dense vegetation concealing frogs |
| 1-Sep | 2030-2130 | Rosen | 29 | Headlamp.2 lg,many calling.1-2 metamorph bullfrogs |
| 2-Sep | 2335-2353 | Rosen | 16 | Headlamp. No calling. Cool. 2 sm bullfrogs |

Table 9. Numbers of captures of two species of garter snakes (genus *Thamnophis*) at San Bernardino NWR, Cochise Co., Arizona, 1985-1995.

| YEAR | *T. eques* | | *T. marcianus* |
|---|---|---|---|
| 1985 | 2 | | 3 |
| 1986 | 8 | | 5 |
| 1987 | 9 | | 7 |
| 1988 | 12 | | 6 |
| 1989 | 12 | | 21 |
| 1990 | | no work on-site | |
| 1991 | | no work on-site | |
| 1992 | 10 | | 10 |
| 1993 | 20 | | 63 |
| 1994 | 14 | | 47 |
| 1995 | 31 | | 218 |
| TOTAL | 118 | | 380 |

TABLE 10. Snakes observed at SBNWR, Arziona, 1985-1995.

| SPECIES | NPOND | LDRAW | CDRAW | UDRAW | ASTIN | TWIN | EVILTW | COTTONW | MESQ | OASIS | 2PHD | TULE | ROBERT | ENCL | BATHH | HOUSE | MAINRD | % of fauna | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Crotalus atrox* | 12 | 2 | 1 | 2 | 1 | 7 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 5 | 5.00 | 33 |
| *Crotalus scutulatus* | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.15 | 1 |
| *Diadophis punctatus* | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.45 | 3 |
| *Hypsiglena torquata* | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.61 | 4 |
| *Lampropeltis getula* | 7 | 1 | 4 | 1 | 0 | 2 | 2 | 1 | 0 | 0 | 3 | 0 | 1 | 0 | 1 | 0 | 2 | 3.79 | 25 |
| *Masticophis flagellum* | 17 | 7 | 4 | 3 | 2 | 11 | 0 | 2 | 0 | 0 | 0 | 0 | 4 | 1 | 2 | 0 | 4 | 8.64 | 57 |
| *Pituophis melanoleucus* | 7 | 0 | 1 | 2 | 0 | 6 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 5 | 3.79 | 25 |
| *Rhinocheilus lecontei* | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0.76 | 5 |
| *Salvadora hexalepis* | 1 | 0 | 0 | 1 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1.06 | 7 |
| *Thamnophis eques* | 35 | 11 | 18 | 0 | 0 | 32 | 10 | 0 | 2 | 0 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 17.88 | 118 |
| *Tantilla hobartsmithi* | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.30 | 2 |
| *Thamnophis marcianus* | 88 | 9 | 3 | 1 | 3 | 93 | 101 | 2 | 1 | 1 | 32 | 2 | 26 | 1 | 7 | 8 | 2 | 57.58 | 380 |
| *Thamnophis* sp. | 3 | 2 | 0 | 0 | 0 | 9 | 4 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 3.33 | 22 |
| TOTAL | 3 | 2 | 0 | 0 | 0 | 9 | 4 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | | 682 |

Figure 1. Bullfrog biomass removals from San Bernardino NWR, Cochise Co., Arizona, 1985-1995. Total includes additional ponds.

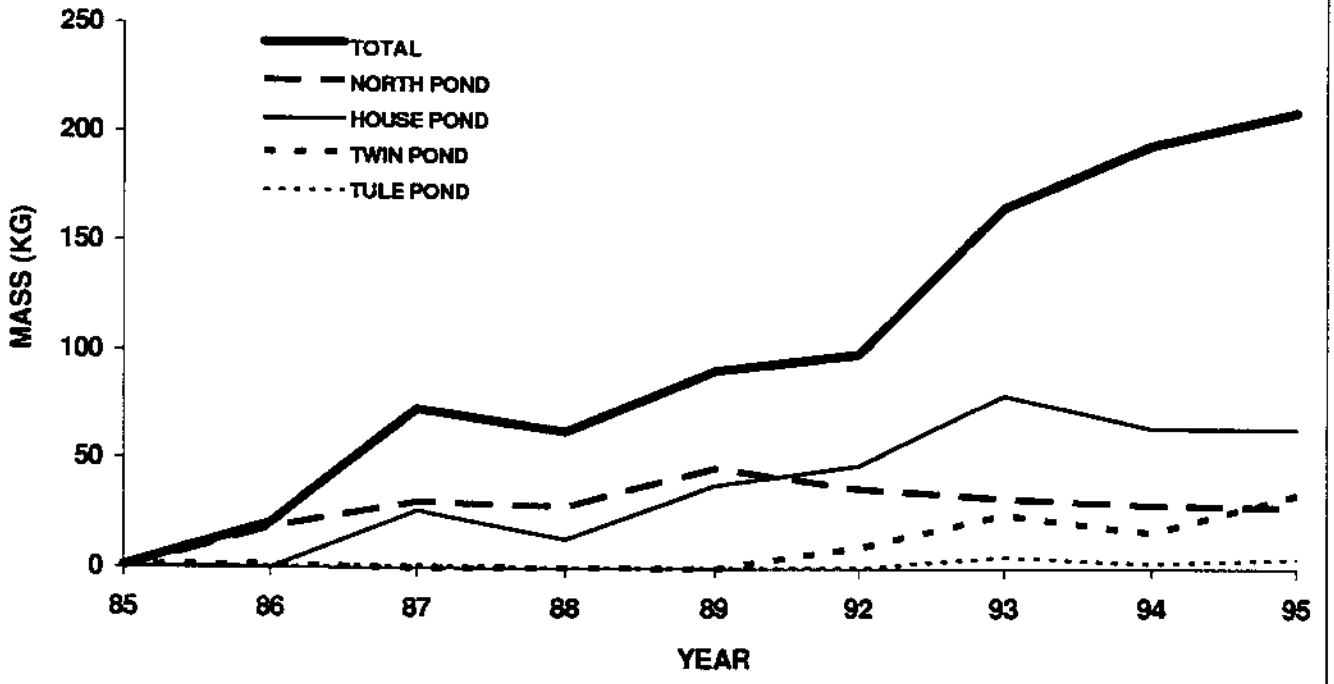


Figure 2. Mean mass of adult and subadult bullfrogs (SVL ≥ 90 mm) at San Bernardino NWR, Cochise Co., Arizona, 1985-1995. Frogs from additional ponds are included in the overall average.

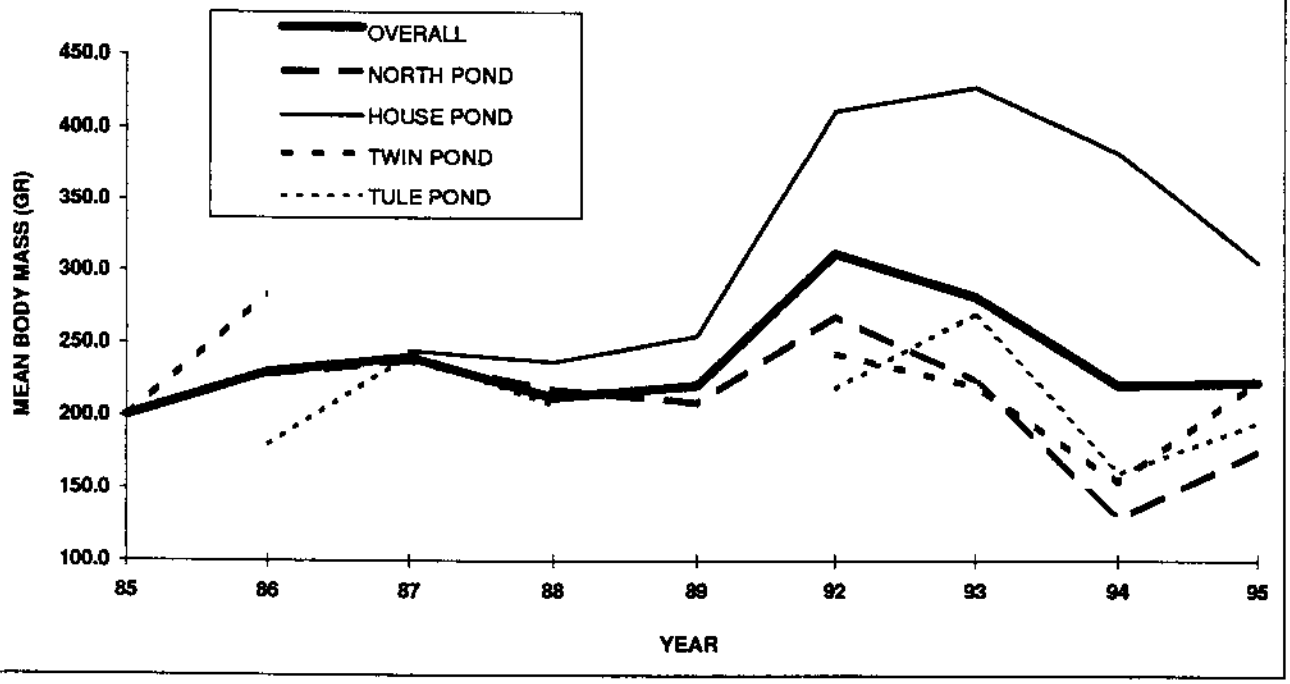

**Figure 3. Monthly trapping results for bullfrogs at San Bernardino National Wildlife Refuge, Cochise County, Arizona, 1993-1995.**