Aquatic and Riparian Herpetofauna of Las Cienegas National Conservation Area, Empire-Cienega Ranch, Pima County, Arizona

Philip C. Rosen, Assistant Research Scientist
School of Natural Resources, University of Arizona
Tucson, AZ 85721 520-621-3187 ph 520-670-5001 fax pcrosen@u.arizona.edu

and

Dennis J. Caldwell, Caldwell Design
2109 N 2nd Avenue, Tucson, AZ 85705 dennis@caldwell-design.com

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Executive Summary

Las Cienegas National Conservation Area encompasses the Empire and Cienega ranches, including the headwaters and intact cienega-stream of Cienega Creek. This area supports the most intact natural major valley bottom wetland in Arizona, and provides a window to the original environment of other valleys in southeastern Arizona. We intensively inventoried the amphibians and reptiles of the cienega and its riparian environs, and extensively surveyed those in the surrounding xeroriparian and upland environments. These environments, not including species in outlying, rocky environments, support a rich herpetofauna with 38 species verified and an expected total of 46 species (including two non-native species), placing it among the richest herpetofaunas in the region. The riparian and cienega vegetation provide habitat for notable populations of more typically montane species such as the Ring-necked Snake, Sonoran Whipsnake, Giant Spotted Whiptail, Madrean Alligator Lizard, Clark's Spiny Lizard, and Slevin's Bunchgrass Lizard, while the sacaton bottomlands and riparian woodlands support such grassland species as the Southwestern Black-headed Snake, Western Box Turtle, Desert Grassland Whiptail, and Eastern Fence Lizard. This assemblage, while unique in some details, exemplifies a regional lowland riparian herpetofauna that has been and continues to be severely impacted in most other sites.

The aquatic herpetofauna of Las Cienegas NCA is also relatively diverse and intact, with two snakes (the Mexican Gartersnake and Checkered Gartersnake), one turtle (the Sonoran Mud Turtle), and three ranid frogs (the Chiricahua Leopard Frog, Lowland Leopard Frog, and American Bullfrog). This aquatic herpetofauna is facing severe threats even though it may be the most intact example of this assemblage in the region. The Mexican Gartersnake was found in low to moderate abundance throughout the cienega system, representing the most significant remaining – though possibly declining – population of this species in the United States. The Checkered Gartersnake, which remains uncommon or rare at Las Cienegas, and the Sonoran Mud Turtle, which is widespread and abundant there, are both successful elsewhere in the region. In contrast, native ranid frogs have suffered widespread regional declines. At Las Cienegas NCA, the Lowland Leopard Frog may be extirpated, and the Chiricahua Leopard Frog has declined severely. It is reduced to three or less known, very small populations, which, nonetheless, are the only known lowland cienega populations remaining in Arizona for this federally listed, Threatened species. These are key research and management populations that represent occupancy of the presumed historical core habitat for the Chiricahua Leopard Frog. The American Bullfrog, which arrived as an exotic invader by 1986, remains

uncommon at Las Cienegas for reasons that remain to be learned. Nevertheless, this exotic threatens the remaining leopard frogs and the Mexican Gartersnake, and may already have had significant impacts on them.

In 1975-6, John Frost found both Lowland and Chiricahua Leopard Frogs in abundance at Las Cienegas, and occurring in sympatric overlap. The population of Lowland Leopard Frogs appears to have contracted downstream, and may now be restricted to the lower reaches of Cienega Creek, in the County Preserve, which is separated from Las Cienegas by several miles of dry streambed. The County Preserve leopard frogs are threatened by an epidemic of chytrid fungus disease. Meanwhile, the Chiricahua Leopard Frog appears to have contracted toward the headwaters. It has bred consistently and successfully only at Empire Gulch Cienega, rather than in Cienega Creek and surrounding ponds, as seen previously. A few individuals have been found in the creek in the past decades, and two recently metamorphosed froglets were seen in 2003 at Cinco Ponds, previously a known site for reproduction prior to the spread of bullfrogs.

Without further research and successful management, both native leopard frogs could be lost from the system. Three areas for research can be identified: (1) survey for disease processes in leopard frogs; (2) investigation of the role of predation, especially by aquatic insects, in preventing bullfrog population expansion and allowing leopard frog persistence; and (3) estimation of the impact of bullfrogs in current, moderate to low abundance on native leopard frogs. The impacts of predation and bullfrog abundance may occur through strong indirect pathways, and may involve fishes, insects, and other predators acting on and through both tadpole and frog stages of the bullfrog and leopard frog life cycles. However, the most immediate need is to secure and enhance the population of the Chiricahua Leopard Frog by finding eggs or small tadpoles, protecting them, and starting a breeding program in a protected facility, preferably on site.

Methods testing for monitoring gartersnakes, ranid frogs, turtles, and interacting species such as fishes and aquatic insects was an important objective of this project. For the Mexican Gartersnake, trapping was superior to on-foot search and hand capture, and simple minnow traps, specially designed funnel trap nets, and aquatic drift fences all were moderately effective. Minnow traps and funnel trap nets were the most tractable in the cienega setting, and both were effective in sampling tadpoles, fishes, and aquatic insects. The funnel trap nets were also useful in sampling turtles. For leopard frogs, auditory search with playback of tape-recorded calls, along with frequent monitoring of known sites, were the most useful methods during our study. Bullfrog removals were accomplished primarily using spears (“gigs”); on-foot searches were required to locate areas for gigging. It remains unclear whether the bullfrog population could maintain itself in the system without immigration from more optimal habitat outside the NCA. We identified a likely source population of bullfrogs upstream from the headwaters of the creek at Cline Pond. Without the elimination of this breeding population, complete eradication of bullfrogs in the preserve cannot be sustained. We successfully removed all bullfrogs from some major reaches of the stream, and such removals may not be fruitless under circumstances in which bullfrog abundance and reproductive success remain low.

Introduction

Ecological Background

Ciénega Creek at Empire Ranch is the most intact lowland aquatic habitat in southern Arizona. It retains the largest, and only substantial, remaining population of Gila topminnow (*Poeciliopsis occidentalis*) in the United States, and also supports a strong population of Gila chub (*Gila intermedia*), both species receiving protection under the Endangered Species Act. A third native fish species, the longfin dace (*Agosia chrysogaster*), also thrives at the site. The Mexican garter snake (*Thamnophis eques*), which has declined or disappeared throughout its range in the United States, also appears to retain its strongest United States population at Ciénega Creek. The site retains a breeding population of the threatened Chiricahua Leopard Frog (*Rana chiricahuensis*), apparently the only one remaining in lowland ciénegas that were probably its historical core habitat in southeastern Arizona. Formerly, this frog overlapped here with its congener, the Lowland Leopard Frog (*R. yavapaiensis*). The Sonoran Mud Turtle (*Kinosternon sonoriense*) also occurs at Empire Ranch, rounding a full complement of the aquatic vertebrates originally inhabiting the ciénegas of southern Arizona.

The riparian environment rivals that seen at Tucson prior to 1900 (Swarth, 1905; Ruthven, 1907; Willard, 1912; Van Denburgh and Slevin, 1913; Brandt, 1951), probably the region's richest; no other known remaining site approaches this. The creek and ciénega support outstanding examples of cottonwood-willow gallery forest, mesquite bosque, and big sacaton bottoms (Hendrickson and Minckley, 1985). These are home to bird species that have become rare through loss of riparian habitats, including the Southwestern willow flycatcher (*Empidonax traillii*), Bell's vireo (*Vireo bellii*), and a great diversity of others. Important lowland populations of riparian and xeroriparian amphibians and reptiles are also known on site. Included in this group are several toads, the checkered garter snake (*Thamnophis marcianus*), Madrean alligator lizard (*Elgaria kingii*), southern plateau lizard (*Sceloporus undulates consobrinus*), and the giant spotted whiptail (*Cnemidophorus burti stictogrammus*). There are, without doubt, a number of other important amphibian and reptile species populations yet to be found centered within the Ciénega Creek riparian area and in the surrounding sacaton grassland. These three elements, the aquatic, the riparian, and the grassland, are, in the listed order, the most threatened elements of our biota in southern Arizona. Ciénega Creek is a conservation resource equal to any other in the region.

The rare species and unusual representation of intact habitat offer an outstanding opportunity to preserve and study the original lowland biota and its ecology. Ciénega Creek appears to be free of immediate threats of direct habitat destruction – water table depletion and bulldozing of habitat for housing development. However, the basin is encircled by regions bristling with non-native species that could invade and eliminate the rarest and most threatened aquatic vertebrates. It seems almost miraculous that harmful fishes have not colonized and eliminated the topminnow and chub. The non-native American Bullfrog (*Rana catesbeiana*) apparently arrived in about 1986 (Rosen, unpublished data), and appears to be slowly spreading from reproductive centers in stock pond habitat nearby (Dennis Caldwell, Jeff Simms, personal communications, 1999-2001). This species may decimate or eliminate populations of native leopard frogs, garter snakes, and mud turtles by predation, larval competition, and transmission of exotic disease (Rosen et al., 1995; Rosen and Schwalbe, 1995; Bradley et al., 2002). Bullfrogs appear to be extremely difficult to remove directly from complex wetlands where they are thriving (Rosen and Schwalbe, 1996). Fortunately, they may not thrive in at least some un-modified habitat types, such as erosive streams and canyons, where bullfrog larvae may be swept away by normal flood scour (Sartorius and Rosen, 2000). However, we have no good examples of what happens in the lowland ciénega environment once bullfrog populations in un-natural stock ponds are removed from the equation.

We know relatively little about the abundance and habitat utilization of riparian gallery forest reptiles in southern Arizona. Most examples of this habitat are so altered, or have been severely degraded for so long, that we have little idea which species utilize them, how, and in what abundance. Our lack of such knowledge clouds any concept for ecological restoration of this rich environment. Much the same could apply for any group of organisms, although the focus here is the herpetofauna. At Ciénega Creek we have the opportunity to inventory, observe, and monitor organisms in a habitat type that once composed the core of the regional landscape, attracting animals and people to the floor of the Tucson Basin and other valleys in southeastern Arizona.

Objectives and Goal

The objectives of this project are to (1) present an inventory of the aquatic and riparian herpetofauna, (2) describe the status and ecology of key species, and (3) evaluate methods that can be used to monitor species trends. The primary species for study issues are the aquatic herpetofauna – the Chiricahua Leopard Frog, Lowland Leopard Frog, Sonoran Mud Turtle, and Mexican Garter Snake, and the non-native American Bullfrog. The secondary focus is the species richness, abundance, and distribution of the terrestrial riparian herpetofauna, and the tertiary purpose was to accumulate information on the herpetofauna of the entire Empire Valley. The goal of this work is to describe problems for the aquatic and riparian herpetofauna, and management and research needed to address them.

Methods

Aquatic herpetofauna were inventoried using survey and trapping methods that have been applied successfully elsewhere in Arizona. Frog distributions were observed by on-foot, at-night surveys using headlamps and binoculars to search for eyeshine, and high-candlepower hand-held lights for ordinary visual search (Rosen et al., 1995; Heyer et al., 1994). Frog calling surveys, dipnetting, and results from trapping were used to identify leopard frog and bullfrog breeding localities. Bullfrogs were captured and removed whenever possible, and efforts were made to eliminate them from entire reaches of stream. Aquatic species were surveyed along the entire perennial region of Ciénega Creek, and in peripheral semi-perennial pools and ponds. We attempted to identify major breeding ponds for ephemeral pond anurans, although these were not found to be very abundant during our study.

Turtles were sampled using hoop nets set for 12-24 hours (Vogt and Hine, 1982; Rosen, 1987; Rosen and Lowe, 1996). Garter snakes were sampled using aquatic drift fences (Rosen and Schwalbe, 1988) set primarily during May-June, and by hand and other types of funnel traps then and at other times. These other traps consisted of standard minnow traps (1/4 inch steel mesh) with funnel opening enlarged to 3-4 cm, collapsible minnow traps (1/8 inch net mesh) with 3 cm openings, and specially designed turtle-type hoop nets (1/6 inch mesh netting) with 30 inch diameter hoops. Traps were identified by laminated signs indicating they were for a University of Arizona study.

Trapped garter snakes were identified to species, photographed if necessary to confirm identification, measured, weighed, sexed by probing, checked for reproductive condition, and marked by both scale clipping and subcutaneous PIT tag injection. Juvenile snakes were PIT-tagged intra-peritoneally, unless they are too small, in which case they were only scale-clipped.

Riparian herpetofauna were sampled by conventional time-constrained field search using conventional visual (and auditory) search, including limited turning of cover. Additional individuals were captured in terrestrial ends of some of the aquatic drift fence traps. Work was conducted at all hours from 0700 to 2400. Field workers recorded start and stop times, methods used, habitats sampled, and locality, date, weather, etc.

We worked to find and gain access to perennial and semi-perennial stock ponds in the Ciénega Creek Basin. These sites were examined and sampled by visual encounter (and auditory, i.e., splash count, calls) survey, and netting (dipnetting, hoop nets, seining, gill nets) as feasible.

Measurements and trapping data (number, time, and locality set, time checked, species observed [including fish, invertebrates, and mammals]) were recorded on data sheets created for the study, and geo-referenced using a Garmin 12 GPS unit (NAD-27).

A database of 36,925 locality records from Pima, Santa Cruz, and Cochise counties, Arizona, was assembled from museums throughout the United States. Each record was classified into a set of geographic sub-regions, and the sub-regions included around the 4 study areas were further classified to isolate records that applied only to the riparian bottomlands and immediately adjoining uplands. Records were excluded if they could not be reasonably determined to fall within the defined study areas. After a first round of classification, these data were re-studied to eliminate ambiguous or misclassified records.

The entire museum database was studied to estimate the sub-region-specific geographic (and inferred habitat) ranges for species, and this was combined with field experience near study areas to define the macrohabitat niche of the species within the sub-region that includes each study area. Species were classified as “RO” (locally riparian obligate) if they only were found and collected within or adjacent to the riparian bottomlands; “R” (riparian associated) if they were found primarily in the riparian bottomlands, but also occurred with some regularity away from it; "C" (common) if they were abundant but not numerically associated with riparian bottomlands; and "p" (present) if they occurred as an occasional record at lower than expected frequency for the taxon.

The final species list for each area was the combined field and museum records available for each species. For the San Xavier-Tucson site, only museum records were included, as recent field data under highly degraded conditions differ markedly from the original conditions found in the literature and museum records. We computed a coefficient of similarity among sites according to the formula $\%\ Similarity = 100 \times 2C/(N_1 + N_2)$, where C is the number of species in common between the sites, and N_i is the number of species at each site.

Results

Species Composition

The total herpetofauna of Cienega Creek and surrounding valley environments at Las Cienegas includes 38 verified species and an expected total of 46 (see appended checklist). Including species that are likely to have populations in adjoining rocky environments, the total may reach 57 species for Las Cienegas. If the county preserve is included, a total of 45 species are currently verified and 62 may eventually be verified for Cienega Creek, not including Madrean woodland species that may occur around the periphery of the lowland environment.

This species density is high: by way of contrast, Organ Pipe Cactus National Monument has 48 species verified, with few or no new species expected to be added to the checklist (Rosen and Lowe 1996), and the Whetstone Mountains support approximately 40 species over an elevational range from 4500 ft on upper bajadas to 7711 ft in ponderosa pine forest. The high species density ("α-diversity") at Ciénega Creek can be emphasized by considering the included elevational range (3800-4600 ft), and for Ciénega Creek in its entirety (exclusive of montane environments, 3100-4800 ft). Six environments are occupied by the expected total of 62 species: Arizona Upland desertscrub, subtropical thornscrub, semi-desert grassland, grassland, riparian woodland, and cienega. At Organ Pipe, the elevational range is 1100-4800 ft, and the four herpetofaunally distinctive environments include from Lower Colorado Valley desertscrub, Arizona Upland desertscrub, montane Sonoran desertscrub (or thornscrub), and Sonoran semi-desert grassland. The Whetstone study, by contrast, includes 8 major environments – all those at Ciénega Creek (substituting Chihuahuan for Sonoran desertscrub) except cienega plus chaparral, Madrean woodland, and pine forest.

Species density at Organ Pipe is roughly similar to that at Las Ciénegas. However, equivalent sampling restricted to the valley environment at Organ Pipe would yield approximately 28 or 30 core species (excluding those present due to proximity of non-valley floor substrata such as nearby rocks), whereas about 35 such core, native species occur in the riparian and semi-desert grassland valley floor environment in the heart of

Las Ciénegas. Thus, it appears that the lowland riparian environment elevates α-diversity to at or near a regional maximum. The lowland riparian at Las Ciénegas supports 2 more anurans, 2 garter snakes, and 1 terrestrial and 1 aquatic turtle above the Organ Pipe valley assemblage, and still supports a high species density of non-aquatic lizards and snakes.

The core faunas at Las Cienegas can be divided in riparian and upland. The riparian element is represented by aquatic, riparian forest, and sacaton and mesquite bottomland species. The upland elements are primarily semi-desert grassland species, but the upper end of Las Cienegas contains grassland species that are found in the Sonoita Grasslands; and thornscrub species are also present in association with thornscrub found in Davidson Canyon, Empirita Mountains, and the lower Madrean aspects of the Santa Rita Mountain biota.

(Thornscrub is a poorly understood biotic community in Arizona: it includes dense Arizona Upland Sonoran "desertscrub" [with well-known plant species] as well as dry tropic scrub [including such species as kidneywood, coursettia, mimosas, and a mix of relatively less xeric-adapted Sonoran and Chihuahuan desert plants]. Thornscrub reptiles in the Arizona Upland herpetofauna include the Sonoran Whipsnake, Tiger Rattlesnake, and Clark's Spiny Lizard; in the dry tropic scrub aspect of the thornscrub in Arizona, there are the Giant Spotted Whiptail, Thornscrub Hook-nosed Snake, Brown Vine Snake, Great Plains Narrow-mouthed Toad, and others.)

There are ten species with riparian associations at Las Cienegas: Western Box Turtle, Giant Spotted Whiptail, Madrean Alligator Lizard, Clark's Spiny Lizard, Eastern Fence Lizard, Slevin's Bunchgrass Lizard, Sonoran Whipsnake, Ring-necked Snake, Common Kingsnake, and Southwestern Black-headed Snake. An eleventh species, the Sonoran Desert Toad, may also be associated with riparian bottomlands at Las Cienegas. Brief discussion of each of these species is provided below.

There are seven aquatic species of amphibians and reptiles at Las Cienegas: American Bullfrog (non-native), Chiricahua Leopard Frog, Lowland Leopard Frog (possibly extirpated), Sonoran Mud Turtle, Mexican Garter Snake, Checkered Garter Snake, and Black-necked Garter Snake (marginally present). The status of these species is discussed below.

Riparian Species Accounts

Sonoran Desert Toad (*Bufo alvarius*), and other toads. We found that summer-breeding desert amphibians were not prominently abundant at Las Cienegas (Map 1). During our periods of study, only 3 Sonoran Desert Toads, 1 Red-spotted Toad (*Bufo punctatus*), 9 Couch's Spadefoots (*Scaphiopus couchii*), and 1 Mexican Spadefoot (*Spea multiplicata*) were seen. A more focused, extensive survey, especially one focused on temporary ponds in the uplands, would likely have yielded evidence of breeding aggregations of these species, but such aggregations were not prominent, and the species were not evidently breeding in numbers on the bottomlands.

Couch's Spadefoot was seen on uplands and near and in the Cienega Creek riparian area. The single observation of a Red-spotted Toad was near the Narrows along the creek. One Sonoran Desert Toad was found at the Mattie Canyon Road crossing. Although the Sonoran Desert Toad was not found in the bottomlands at all, it may be expected there, based on observations elsewhere.

Certain toads were conspicuous by their absence – especially the Great Plains Toad (*Bufo cognatus*), which has a very loud call that is often heard over many weeks or even months within a year. Museum records indicate this toad is absent from a broad swath of territory between Tucson and Benson, and extending down through Sonoita and Nogales, whereas it is widespread and abundant through the rest of southeastern and south-central Arizona.

A more thorough search for these species may be warranted to determine their contribution to overall tadpole, and thus tadpole predator, abundance at Las Cienegas.

Western Box Turtle (Desert Box Turtle, *Terrapene ornata luteola*). Box turtles are not common at Las Cienegas, but maintain a significant population associated with the bottomland sacaton and mesquite. We have only 6 records (Map 2; 2 tracks, 2 shells, and 1 live in 2003; 1 drowned in stream in 1998 [J. Simms, personal communication]), although we made an effort to find them during 2003. The records are in or near the riparian bottom; and box turtles have not been recorded in museum collections from the highway; and the only record from the Whetstone Mountains region is from Kartchner Caverns park, in the San Pedro Valley (Turner et al. 1999). Box turtles are also uncommon in the Sonoita Grasslands, where we have seen them after rains on the O'Donnell Canyon bottomland on the Appleton-Whittall Research Ranch. The species was formerly found on the Rillito, the Santa Cruz River, and elsewhere in major riparian corridors in the Tucson Basin, and they may still persist in part of the Tanque Verde. The population at Las Cienegas is significant in this context as a representative of a lowland semi-desert riparian population that was almost lost during the past century. A more focused study of these populations may be warranted: one objective would be to determine the relative importance of riparian versus grassland environments for this subspecies.

Giant Spotted Whiptail (*Aspidoscelis burti stictogramma*). (This taxon was formerly *Cnemidophorus b. stictogrammus*; it is currently regarded as a subspecies of the Canyon Spotted Whiptail). The discovery of the Giant Spotted Whiptail in Davidson Canyon 2001 (Rosen et al. 2002) and at Las Cienegas in 2002 (this study) completes a revision of our understanding of the habitat of this subspecies in Arizona. Previously considered to be a canyon (montane) species, it is now known to maintain significant populations in lowland riparian environments where these retain some of their original characteristics. Current occurrence in the original lowlands is known only at Las Cienegas, Tucson (West Branch of the Santa Cruz River, Tanque Verde), Santa Cruz River and Potrero Creek near Nogales, and possibly the San Pedro River near Babocomari River confluence (Corman 1988). Based on these findings we can now infer that the distribution of this taxon was likely much wider prior to desiccation of lowland streams and degradation of their associated riparian woodlands and forests. The Las Cienegas population is currently the most representative example of occupancy of this habitat by the Giant Spotted Whiptail. At Las Cienegas, we recorded a respectable 53 observations of this taxon, distributed over most of the study reach (Map 3). It was found in the streamside riparian, and apparently largely restricted to it and adjoining mesquite environments. Turner et al. (1999) found this species frequently in the northern portion of the Whetstone Mountains and "all across the adjoining alluvial plain" (bajada) of those mountains.

Madrean Alligator Lizard (*Elgaria kingii*). We recorded 6 alligator lizards in 2003, and previously saw one in 1996 (Map 4). This is generally regarded as a montane forest species, and the numbers recorded at Las Cienegas – considering the species is secretive and not easily observed by our methods – support our recognition of the alligator lizard as an important participant in lowland riparian systems in southeastern Arizona. It has also been found at San Pedro River NCA (Corman 1988), La Cebadilla Spring (Tucson Basin), Santa Cruz River and Potrero Creek near Nogales, and San Bernardino NWR (Rosen et al., submitted). Although our records are concentrated in the upper (southern) portion of Las Cienegas, we suspect records will eventually be obtained throughout the riparian area proper, and perhaps in some grassland and mesquite environments. Turner et al. (1999) observed 22 E. kingii in the Whetstone Mountains, between 4500 and 6200 ft elevation, but none were on the west side adjoining the lowland population at Las Ciénegas.

Clark's Spiny Lizard (*Sceloporus clarkii*). This large spiny lizard is known as a lower Madrean species in Arizona, but it also occurs widely in thornscrub within the Sonoran and Chihuahuan desert zones, especially on rock slopes. It is prominent in mountain riparian zones, and is found, sometimes in abundance, in all remaining patches of healthy lowland riparian environment in southeastern Arizona. Formerly, at least, it occurred as far out into the Sonoran Desert as the mission at Komatke, on the Gila River southwest of Phoenix. In other areas, this species is (increasingly) being replaced by the Desert Spiny Lizard (*S. magister*).

At Las Cienegas, Clark's Spiny Lizard has generally been found throughout the riparian area. We have several records from productive upland sites, as well, and expect this species wherever sizable trees occur. Although we recorded only 29 observations during 2002-3 (Map 5), this species is fairly abundant.

Eastern Fence Lizard (*Sceloporus undulatus*). The taxonomy of this species is in flux. Previously, the species was represented in southern Arizona by the Southern Prairie Lizard (*S. u. consobrinus*), a valley-dweller, whereas those from the Catalina Mountains and in central Arizona were assigned to the Southern Plateau Lizard (*S. u. tristichus*), a rock and mountain form. Recent study of mitochondrial genetics calls this into doubt (Leache and Reeder 2002), and identifies the local form as a separate species, *S. cowlesi*. For the time being, we have maintained a conservative position in retaining the original name at the species level.

Although typically associated with grassland floors in Cochise County, the fence lizard was known from all major riparian lowlands in southeastern Arizona, including at downtown Tucson. Thus, its presence at Las Cienegas offers another example of the original conditions prevailing in the Tucson region. We recorded 34 observations of this species at Las Cienegas in 2002-3, although no special efforts were made to find or sample for *Sceloporus*. It is abundant in the riparian area and in bottomlands with trees and woody debris, and was found at one upland site, near Cottonwood Windmill (Map 6). However, it is probably dependant on the riparian zone for it persistence at Las Cienegas.

Slevin's Bunchgrass Lizard (*Sceloporus slevini*). Formerly called the Bunchgrass Lizard (*S. scalaris*), this is normally a higher eleveation species found in bunchgrasses in pine and pine-oak woodland, and also in southern Arizona in lower numbers (apparently with severely fluctuating populations [Smith et al. 1998]) in grassland in the Sonoita Grasslands and San Raphael Valley. Its occurrence at Las Cienegas was unexpected, and represents a low elevation extension of its distribution along the riparian bottomland. Turner et al. (1999) only found 2 of these in their intensive Whetstone Mountains survey, on the highest ridges in the range. Our records for 2002-3 show it only right along the cienega-stream riparian, but it was found near Cinco Ponds in 2004 (PCR, photo voucher). Thus far, all records are for the upper (southern) portion of Las Cienegas (Map 7), and it may not descend far below our lowest point at about 4300 ft elevation.

Sonoran Whipsnake (*Masticophis bilineatus*). The Sonoran Whipsnake is a Madrean Woodland and thornscrub species that is prominent in Arizona Upland Sonoran desertscrub on richly vegetated rock slopes. Although it may follow riparian corridors to lower elevations, it appears to be no better adapted to them than the more desert-adapted Coachwhip (*M. flagellum*), which seems to replace this species in a gradual transition with decreasing elevation. Both species are found at Las Cienegas and in the surrounding uplands, although the Coachwhip is less closely associated with the riparian zone at this site. The Sonoran Whipsnake occurs at the lower (County Preserve) reach of Cienega Creek, but is apparently absent on the Tucson Basin floor, and it is rare or absent at San Bernardino NWR at 3700 ft elevation.

At Las Cienegas, as at Babocomari, however, we regard it as a characteristic component of the streamside riparian zone. However, all of our 7 records are near the Narrows and the Mattie Canyon confluence (Map 8), where rockier environments approach the stream. In contrast, upstream whipsnake records (n = 3) were Coachwhips. The relationship between these two species, which usually replace one another ecologically – sometimes with a sharp dividing line – is not entirely clear at Las Cienegas.

Previous to our 2002-3 studies, it appeared that the Sonoran Whipsnake was in significantly greater abundance along the stream, particularly in the Mattie Canyon confluence (Shangri-La) area that we previously surveyed in 1985-6 and 1997-2000. We have no explanation for this change, if it is real.

Ring-necked Snake (*Diadophis punctatus*). The Regal Ring-necked Snake (*D. p. regalis*), a relatively large, boldly marked form sometimes considered a full species, is the taxon represented at Las Cienegas and elsewhere in the Southwest. Although often found as a grassland and woodland species here, it follows lowland riparian systems deep into the Sonoran Desert, and was recorded at San Xavier, near Tucson, as late as 1939 (Arnold 1940). It is a secretive subspecies with snake-eating proclivities, and thus is high on the food chain and not normally very abundant. Thus, our three records (Map 9) indicate a significant population, and though it is most likely largely confined to the cienega and sacaton bottomlands, it probably occurs throughout the south-north length of Las Cienegas.

Common Kingsnake (*Lampropeltis getula*). We only found 1 Kingsnake during 2002-3, along with one on the highway in 1996, and one reported by a colleague in 2004 near the bottomlands. This species is often seen in regional riparian areas and near ponds and springs. The paucity of records is surprising for such a normally conspicuous species, and perhaps a matter of chance.

Southwestern Black-headed Snake (*Tantilla hobartsmithi*). Although we only obtained two black-headed snake records, both of this species, our efforts were not designed to locate it, and it is probably fairly abundant. One of our records was from an upland well site, and the other from The Narrows (Map 9). This species follows lowland riparian zones, as well as relatively productive desert mountain canyons, out into the desert past Gila Bend and to the Ajo Mountains at Organ Pipe Cactus National Monument, but it is more usually a desert grassland-associated species. At Las Cienegas it probably occurs in Semi-desert Grassland uplands as well as in the bottomlands. A more focused study would likely show this, and might possibly also reveal the presence of two other tantillas, the Yaqui Black-headed Snake (*T. yaquia*) and the Plains Black-headed Snake (*T. nigriceps*).

Aquatic Species Accounts

Lowland Leopard Frog (*Rana yavapaiensis*). Although the Lowland Leopard Frog occurs to at least 5,500 ft elevation, populations usually occur primarily below 4,100 ft; in contrast the Chiricahua Leopard Frog occurred at least as low as 3455 ft (Aguirre Lake at Buenos Aires NWR), and its occurrence below about 3,700 ft is unusual. The elevational range of Cienega Creek at Las Cienegas ranges about 3936 – 4430 ft, while the County Preserve reach flows down from its normally perennial source at 3518 ft. Thus, it is not surprising that that lower reach has supported (and still does) the Lowland Leopard Frog, whereas Las Cienegas supported both species, with the Lowland Leopard Frog high in its normal elevational range.

We have not verified the occurrence of this species at Las Cienegas since vouchered museum records and detailed observations by John Frost in 1975-6. However, leopard frogs seen at near the Mattie Canyon Confluence in 1985-6 looked like Lowland Leopard Frogs (Rosen, *pers. obs*.), one reported at The Narrows in 1998 may have been this species (J. Simms, *pers. comm*.), and an unidentified leopard frog seen there in March

1995 (Rosen, *pers. obs*.) could have been this species. Further, this species is reported to persist, perhaps precariously, in Wakefield Canyon at Wakefield and Little Nogales springs at 3,900 – 4,600 ft (Turner et al. 1999; Russell Duncan, D. Turner, J. Fonseca, *personal communications*, 1998-2002). Thus, it is reasonable to suspect it may still be present at Las Cienegas, or that it may re-colonize in the foreseeable future.

Frost (*unpublished field notes*, courtesy of Philip Fernandez and Joseph Bagnara) reported that Cienega Creek was a site of direct sympatry (syntopy) of Lowland and Chiricahua Leopard Frogs (then called "lowland" and "southern" forms). We interpret Frost's field notes to imply that this occurred and was observed near the main road crossing in the vicinity of Cienega Ranch, where the elevation is 4,300 ft. The notes indicate that leopard frogs were clearly more abundant than during our period of observation, 1985 – 2003. This is generally synchronous with other apparent declines in abundance and distributional ranges of leopard frogs in southern Arizona (Clarkson and Rorabaugh 1989). The causes of these declines are various, but two seem likely for the Lowland Leopard Frog at Las Cienegas – disease and metapopulation decline.

The emerging amphibian disease chytridiomycosis, caused by the chytrid fungus *Batrachochytrium dendrobatidis*, was first confirmed in the wild in North America in a Lowland Leopard Frog from 1997 at the County Preserve reach of Cienega Creek (see Bradley et al. 2002), although the disease has since been confirmed for southern Arizona back to 1972 (Pajarito Mountains, Mike Sredl, *pers. comm*.). It seems plausible that this disease spread through the Las Cienegas region in the interim between Frost's work and ours, perhaps in the early 1980's, reducing leopard frog populations markedly or causing local extinctions. Jeff Simms (*pers. comm*., 1996) reported seeing dead frogs during fall sampling in the lower reaches of Las Cienegas in years prior to 1995. Also during the 1970's through 1990's, harmful non-native species spread rapidly through landscapes in southeastern Arizona (see Rosen et al. 1995), apparently eliminating many of the abundant pond populations described in Frost's notes by the time of Clarkson and Rorabaugh's (1989) re-surveys in the mid-1980's. According to Frost, and as expected, some of these populations had very high reproductive success, and would have likely contributed migrants to sustain and re-establish nearby populations. Thus, it seems plausible that both disease (directly) and introduced species (indirectly through metapopulation decline) contributed to a regional decline of the Lowland Leopard Frog, and that both may have been involved in the decline of leopard frogs at Las Cienegas, and particularly in the apparent extirpation of the Lowland Leopard Frog there.

Chiricahua Leopard Frog (*Rana chiricahuensis*). We focused intensive survey and monitoring on this species, which was listed as Threatened under the federal Endangered Species Act on June 13, 2002. It has been rare, yet persisting, at Las Cienegas for a decade or more as of this writing. We found it (Map 10) only at the spring at Empire Ranch (Empire Gulch Spring), at 5 spots in two groups (Headwaters and Cattle Crossing) over a 1.4 mi-long reach in Cienega Creek from the headwater spring to the area where the broad bottom land of Empire Gulch contacts the Cienega Creek bottomland, and at Cinco Ponds.

During 2002-3, we consistently found evidence of successful reproduction only at Empire Gulch Spring, a site that is isolated by about 3 miles of Empire Gulch bottomland from the nearest site where we were able to detect other Chiricahua Leopard Frogs. At this site, we made frog observations on 20 dates during 2002-3, seeing 0 – 15 transformed frogs, and 0 – 16 tadpoles, with total observations ranging from 2 – 18 individuals. Although observations were difficult to make in the dense vegetation at Empire Gulch, it was apparent that this was a small population, with observations averaging 5.7 frogs/visit and 7.0 individuals/visit. At this small population size, probably averaging less than 20 adults, our observations indicate a remarkable level of stability in numbers (Fig. 1), and J. Simms (*pers. comm*. 1996) also indicated small, but consistent numbers of leopard frogs at this site during the early and mid-1990s.

Monitoring results for Empire Gulch Spring consisted of careful searches for frogs, especially at night. The work began with incidental observations in 1997, and continued more formally starting in 1999 in connection with disease studies. The zero value for 2000 is of limited concern because it is based on two mid-winter surveys looking for dead or moribund frogs stricken by chytrid fungus, and frogs might have been present but unobserved due to cold or by chance. Two dead frogs were seen in 2002, but these appeared to have been killed by giant water bugs (Belastomatidae: *Lethocerus medius*). In early 2004 a partly decomposed adult was found that might have died from disease; however, the specimen was too decomposed for disease testing.

One Chiricahua Leopard Frog that was accidentally killed in 2001 was tested, and was histologically negative for the chytrid pathogen. Thus far, this remains one of a few leopard frog sites in southern Arizona that has failed to yield a chytrid-positive test and evidence of disease-related mortality. Absence of disease may contribute to population stability at such sites. We have exercised care to avoid bringing disease to this isolated site, and this should be an important consideration for all researchers and managers working in the mud and water at Empire Gulch.

Chiricahua Leopard Frogs were also seen and heard calling in Cienega Creek, but neither tadpoles nor metamorphs were found: all observed individuals have been adults (including in 1996); we dip-netted and trapped extensively in the creek without detecting leopard frog tadpoles; thus, it is not clear that there is successful reproduction in the creek.

The only other site where we saw leopard frogs was Cinco Ponds. In 1989, a bloom approaching 100 metamorph Chiricahua Leopard Frogs at this locale was documented and vouchered in 1989 by Jeff Simms and Peter Warren. The only other documented occurrence of the species there was in 2003, when we found 5 recently transformed metamorphs during 4-13 July. It seems likely that there is at least occasional reproductive success of this frog in Cinco Ponds. In 1996, we were unable to observe leopard frogs in Cinco Ponds.

The status of the Chiricahua Leopard Frog at Las Cienegas is precarious, even though we accumulated 156 records in 2002-3 and 302 overall from 1985-2003. In an interview on

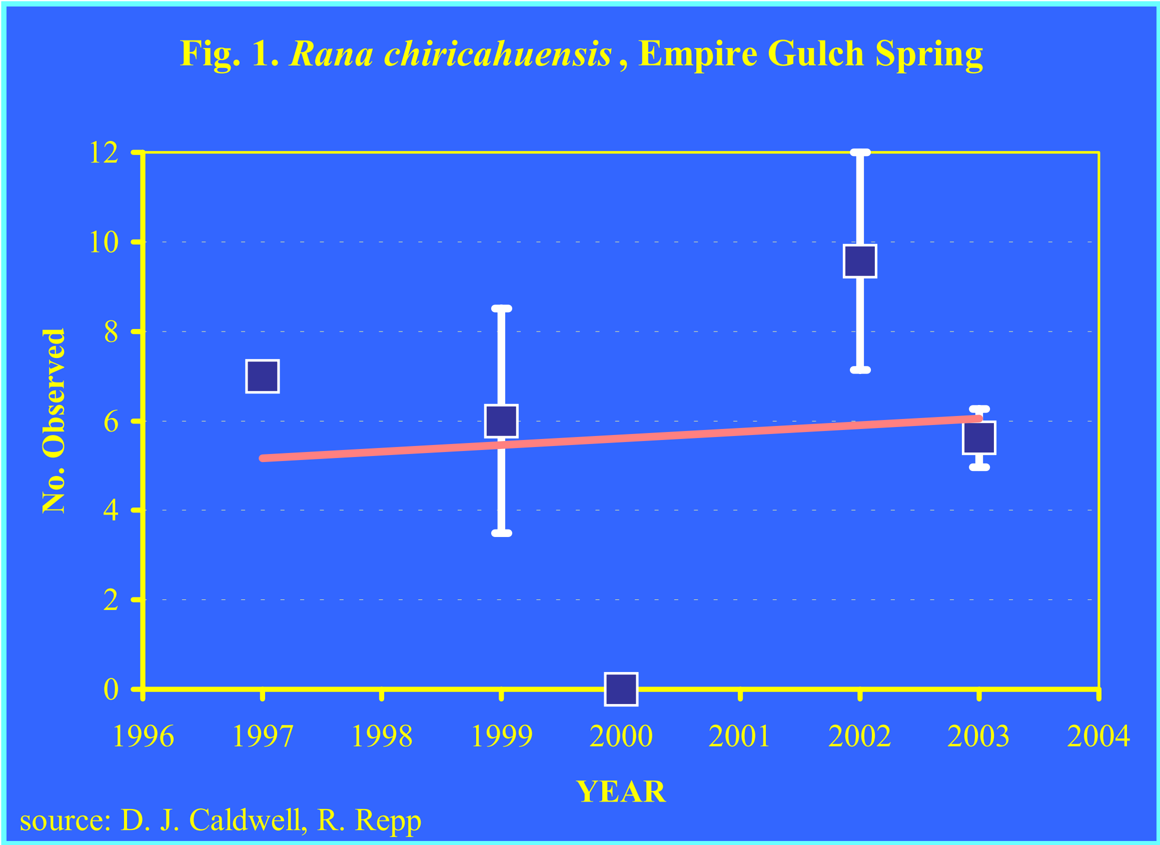
Fig. 1. *Rana chiricahuensis* , Empire Gulch Spring
No. Observed
0
2
4
6
8
10
12
1996
1997
1998
1999
2000
2001
2002
2003
2004
YEAR
source: D. J. Caldwell, R. Repp

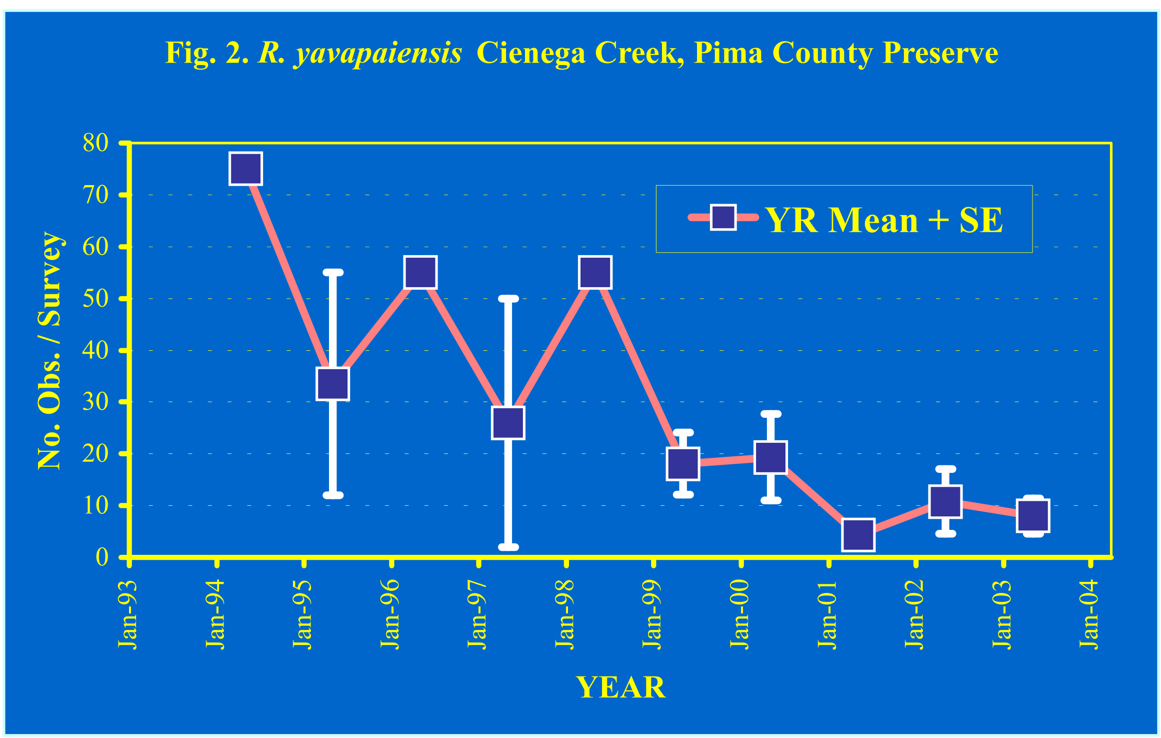
Fig. 2. *R. yavapaiensis* Cienega Creek, Pima County Preserve
No. Obs. / Survey
0
10
20
30
40
50
60
70
80
YR Mean + SE
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
YEAR

17 June 1996, J. Simms described finding leopard frogs, most likely Chiricahua Leopard Frogs, in numbers at Cinco Ponds and in the fishless perennial stream in lower Empire Gulch as recently as 1994 (though PCR failed to find them there in 1996), as well as seeing small, but consistent numbers in the reach from the headwaters to Springwater Canyon. Along with John Frost's notes, this confirms that our findings represent a marked decline in this species over the past 3 decades. With the very limited numbers and reproduction we found recently, extinction could occur quickly and by chance. Population processes that may be at work in ranid populations at Las Cienegas during our study will be discussed in a separate section below; here, we suggest that preparations should be made for tadpole rearing and head-starting in controlled, outdoor facilities on-site, which can be stocked with a portion of an egg mass (50 or more eggs) or at least 6-12 tadpoles when there are a suitable opportunities to obtain these without impacting natural populations at Las Cienegas.

Table 1. Numbers and age distribution of bullfrogs recorded at Las Cienegas in 2002-3.

Site, Stream Reach	Lg AD	AD	Sm AD	SubAD & JUV	Larva	undet.	Total
				2002			
Creek, Headwaters	0	0	0	0	0	0	0
Creek, Gardner confluence	1	3	0	0	9	0	13
Creek, Springwater confluence	1	14	1	17	0	8	41
Creek, Mattie confluence	1	1	1	0	0	0	3
Cinco Ponds	0	26	32	35	0	0	93
2002 Total	**3**	**44**	**34**	**52**	**9**	**8**	**150**
				2003			
Creek, Headwaters	8	20	0	0	6	0	34
Creek, Gardner confluence	7	12	0	41	21	0	81
Creek, Springwater confluence	2	10	1	0	0	0	13
Creek, Mattie confluence	0	0	0	0	0	0	0
Cinco Ponds	16	43	5	0	0	0	64
2003 Total	**33**	**85**	**6**	**41**	**27**	**0**	**192**
Overall Total	**36**	**129**	**40**	**93**	**36**	**8**	**342**

American Bullfrog (*Rana catesbeiana*).

Historical Information. In 1984-5, bullfrogs were not observed during visits to the Mattie Canyon confluence area by PCR in company of Arizona State University ichthyologists, but in 1986-7, on Mexican Garter Snake surveys there, an adult was heard calling. During 1985-1988, no additional bullfrogs were seen at Babocomari or at the Elgin Research Ranch, or anywhere else in the area including the Canelo Hills, Sonoita Grasslands, Elgin, Babocomari Ranch, and Ciénega Creek in the lower (Pantano-Vail) reach. By 2000, bullfrogs were abundant at Babocomari, had invaded Finley Tank at Research Ranch, and were briefly present in Post Canyon at Research Ranch (Rosen et al. 2002). They were also widespread at Las Ciénegas at that time, occurring in moderate numbers at Road Canyon Tank and Cinco Ponds, and in low numbers throughout much of the creek.

The source of the bullfrogs may be in Northwest Reservoir (= current Phelps Dodge property, Mud Spring Canyon Reservoir, also known as "Clyne Pond", where a rancher reports having introduced them. The reservoir was reportedly put in about 1978, and the bullfrogs imported from Texas a few years later. As of 2 May 1991 it was 2145 m^2 in area, 4.7 m deep, and had largemouth bass, bluegill, and goldfish (smallmouth bass, bluegill, and possibly catfish were in Masek Pond) according to K. Simms (1991). Brown (1991) sampled the NW Reservoir 30 Jan. – 10 Feb. 1991, and found many 1.5 lb. largemouth bass and ½ lb. bluegill, hundreds of small bluegill, 1 small bass, one 2 lb goldfish, and a few bullfrog tadpoles. We visited Masek Pond in 2003 and found it as described, with various non-native fishes but no bullfrogs. We have not visited Northwest Reservoir, but local residents report bullfrogs numerous there as of 2003, and that bullfrog regularly appear after rains at ponds one or more miles to the east. It seems plausible that the introduction of bullfrogs at Clyne Pond has led to their spread throughout a previously un-invaded area.

Northwest Reservoir bullfrogs could easily get to Road Canyon Tank, and from there to Ciénega Creek headwaters. They could also go down Mud Springs Draw to Ciénega Creek, or across a headwaters flat to Springwater Canyon and then down into Ciénega Creek. This pond also places bullfrogs within known dispersal distance (> 6 mi, D. Suhre *unpublished*) of Babocomari River at Elgin. Bullfrogs could also have ascended 18 miles up the Babocomari River from the San Pedro River, where they were already established and abundant by 1985 (Rosen and Schwalbe 1988).

Road Canyon Tank supported a breeding population of bullfrogs until 2002, when an annual drying regime was initiated.

In 2002-3, we made 342 observations of individual bullfrogs, and removed 173 (Table 1).

Distribution (Maps 11 and 12). Bullfrogs were widespread but non ubiquitous at Ciénega Creek during 1999 to 2002-3. They occurred, but were not found to have bred, in the

County Preserve reach in 2000, but after floods filled in deeper pools, and bullfrogs were manually removed, they appeared to have disappeared there by 2002. In 2002, Trevor Hare found a stock pond population near Pantano Substation, below The Narrows; although no frogs were found there during a survey in 2003, there may be other source populations in that general (and largely unsurveyed) area. At Las Ciénegas, we recorded them in Cinco Ponds, from Headwaters to Springwater confluence in the stream, and near the tilted beds in the stream near Mattie Canyon. We found them abundant in Cinco Ponds, with tadpoles observed in spring 2004 but not during 2002-3. They were uncommon in the stream, with small numbers of tadpoles observed in the stream from the source almost down to the Gardner Canyon confluence. In 2002, our removals seemed to have succeeded in removing all the bullfrogs from the Mattie Canyon portion of the stream, and they were not observed downstream from Springwater confluence in 2003. It appeared that our successful bullfrog removal was aided by denudation of the stream vegetation by errant cattle in 2002.

The distribution we observed within the stream corresponds to the distribution of deep, “slit pools” with perennial water. Slit pools occur from the headwaters source to a short distance below the Oak Tree Canyon confluence. Then the creek gradually dries, and is muddy to dry from below the old road crossing near the Springwater confluence to the main road crossing near Cienega Ranch, and no bullfrogs were ever found by us below the Springwater confluence. Although J. Simms reported bullfrogs prior to 1996 in the cienega marsh north of the main road crossing to Ciénega Ranch, we were unable to locate any there. Slit pools then occur again in the middle of section 23, north of the formerly farmed Ciénega Ranch flats, just where the bullfrogs reappeared. Below the Mattie Canyon confluence (the “Shangri-La” area), slit pools are few or absent, and we have not recorded bullfrogs. Although there are slit pools in The Narrows, no bullfrogs have been seen there, possibly because scour is more intense where the bottomland is constricted by the rocky and stony environment of The Narrows area.

Bullfrogs invaded Ciénega Creek at Las Ciénegas between the mid-1970s and 1986, and probably around 1985. Although they have occurred for nearly two decades, and have been found throughout Ciénega Creek, they have remained rare to uncommon in the stream. Moderately high densities have occurred at Cinco Ponds and Road Canyon Tank (now dried annually to prevent bullfrog reproduction), and, apparently in Northwest Reservoir. The small, low-density populations achieved by the bullfrog in Ciénega Creek are markedly different from those seen in most other parts of southeastern Arizona.

Age Structure. The largest numbers of bullfrog records were obtained from Cinco Ponds, and Gardner Canyon confluence, and Springwater Canyon confluence reaches area of Cienega Creek (Table 2). It appears that *in situ* reproduction influences the abundance of bullfrogs in local areas within Las Ciénegas. For example, tadpoles were seen only at Gardner Canyon reach in 2002, and the number of frogs recorded there, and in the upstream adjoining (Headwaters) reach increased markedly from 2002 to 2003. Meanwhile, tadpoles were not recorded in the Springwater and Mattie Canyon reaches, and the numbers recorded dropped markedly from 2002 to 2003.

In a similar way, the age structure at Cinco Ponds in 2002 was composed of small adults, subadults, and very few medium-sized adults, with the lack of metamorphs and smaller juveniles indicating that reproduction probably did not occur there that year, and that the population was derived from reproduction in 2001, either at Cinco Ponds or elsewhere. Although 93 were recorded (and almost all of them removed) in 2002, in 2003 there remained a significant number of large adults and medium-sized adults, with few small adults and no pre-adults recorded. This indicates that there was little or no successful reproduction by bullfrogs in Cinco Ponds in 2002, either because the adults did not mature in time to breed, because we removed most of them as they matured, or for some other reason. Given the vegetation density at Cinco Ponds and the level of removal effort, it is not surprising that some adults survived our removal efforts. In spring 2004 we found large bullfrog tadpoles and small metamorph bullfrogs in Cinco Ponds for the first time. This appears to reflect reproduction in late summer 2003 by some of the larger adults that we, presumably, failed to remove.

Bullfrogs had been present at Las Ciénegas for at least 17 years when we began the study in 2002. They can disperse 6 or more miles per year in semi-desert grassland (Suhre et al. *manuscript*). Thus, it seems unlikely that we witnessed the first colonization of Cinco Ponds or any reach of the creek during 2002-3. Instead, the data suggest that reproductive success and abundance of bullfrogs varies markedly in time and space at the site. The small numbers found and removal success in the lowermost reaches indicates that bullfrogs have fared poorly there. In the Springwater to Headwaters reaches, reproduction occurred in both 2002 and 2003, and it appears possible that while 2002 reproduction was only locally successful, it sufficed to contribute subadults to the 2003 population. Despite this evidence of *in situ* reproductive success, abundance appears to have remained low throughout Las Ciénegas.

We have not evaluated the significance of long-distance dispersal of bullfrogs into Ciénega Creek, but suspect it currently comprises a minor part of recruitment into the population. However, such dispersal will definitely compromise any concerted effort to permanently eliminate the bullfrog from Las Cienegas.

Sonoran Mud Turtle. We found Sonoran Mud Turtles in all the perennial waters of Las Ciénegas that we investigated (Map 13). The species was abundant throughout, except that only a single record was obtained from Empire Gulch Spring. We recorded over 354 observations of individuals during 2002-3, although we made no intensive efforts to capture or observe turtles. Although a few individuals were marked, we did not obtain recaptures; it seems very likely that the species probably numbers in the thousands at Las Ciénegas. Such high numbers and densities were also seen, during 1983-1988, at Babocomari, Post Canyon, Turkey Creek, and ciénegas in the lower San Raphael Valley. These turtles are also conspicuous at the County Preserve reach, but they are much less abundant there, probably because there is less protective cover and more intense, episodic mortality from flood scour (see Rosen 1987). Turner et al. (1999) observed them in springs in and near Wakefield Canyon and at Simpson Spring, on the west side of the Whetstone Mountains. We found a juvenile Sonoran Mud Turtle, along with a subadult Mexican Garter Snake, in a large adult female bullfrog taken from the headwaters pool of

Cienega Creek in June 1996; and another juvenile turtle in another large adult female bullfrog in April 2003 from a pool near Gardner Canyon confluence.

Black-necked Garter Snake. Only one Black-necked Garter Snake was recorded in our data set, observed by J. Simms in The Narrows area, between Apache and Fresno Canyons in 1990. This species normally lives in canyon environments, with less vegetation density than seen in mature ciénegas. Its reported presence at The Narrows is not entirely unexpected, as (1) individuals are occasionally found in valley grasslands, (2) the species was observed in the County Preserve reach in 1985 (Rosen and Schwalbe 1988), and (3) another rocky canyon species, the Red-Spotted Toad, was also recorded at The Narrows. The Black-necked Garter Snake is abundant in major canyons in the Whetstone Mountains (Turner et al. 1999), and is in Gardner Canyon in the Santa Ritas (PCR, 1994 observations).

Checkered Garter Snake. We found a single Checkered Garter Snake in 2003 along Ciénega Creek near the Gardner Canyon confluence, and trapped one at Cinco Ponds in 2004. These are the first records for the species from Ciénega Creek. Although the species has not been found at the County Preserve, it is abundant in the Sonoita Grasslands. In distinction from the Mexican Garter Snake, juveniles of this species tend to be less aquatic than adults, and are thus less exposed to predation by bullfrogs; this species has replaced the Mexican Garter Snake in a number of sites where bullfrogs have strong impacts (Rosen and Schwalbe 1998; Rosen et al. 2002).

Mexican Garter Snake. We observed 29 Mexican Garter Snakes at Las Ciénegas during 2002-3; 1 was found during snake surveys in 2000; 1 was found in a bullfrog in 1996; and 4 were hand-captured in two survey passes in 1986-7 (Rosen and Schwalbe 1988, 2002). Our 2002-3 total is encouraging in displaying a persisting population, although the number of captures is low considering our focused efforts to obtain hand captures (9 visual observations in 2 years) and trap captures (21 trap captures in 491 trap-days using a variety of trap types, including 6 captures in 163 trap-days using fence traps (0.037/trap-d) that have yielded 0.1-1.6/trap-d in other Mexican Garter Snake populations [Rosen et al. 2002]). Although these traps are difficult to use with deep water, steep banks, and fluctuating water levels, which we confronted at Las Ciénegas, all the capture and observation rates were lower than expected in 2002-3, whereas the limited work during the 1980's suggested a larger population. Population decline during the 1990's was demonstrated or probable in most Mexican Garter Snake localities re-surveyed in southeastern Arizona (Rosen et al. 2002), and our results are consistent with those findings.

The observed distribution of the Mexican Garter Snake at Las Ciénegas in 2002-3 reflects the distribution of our most intensive trapping (Map 14), with some gaps filled by visual locations of individuals. This species occurred widely in perennial stream sections, and 4 were found on the floodplain bottoms away from the streams and major ponds, at ponds and pools where the Checkered Garter Snake might have been expected. We did not record it at Empire Gulch Spring, but we did little trapping or invasive sampling there in order to avoid impacts on the leopard frog population. Gaps in the observed distribution in the bottomlands and along the stream may be attributed to sampling limitations; the species clearly remained widely distributed, though perhaps reduced in abundance, at Las Cienegas in 2002-3.

Sampling Methodology

The largest number of our observations of amphibians and reptiles at Las Ciénegas in 2002-3 came from visual and auditory search (1,692 records; Table 3), while trapping yielded 166 records (Table 2), and lethal means (gigging and shooting) yielded 140 records. The hoop nets used were custom made with 1/6-inch mesh; these were only used during the latter part of the study, and were effective in capturing turtles, bullfrog larvae, and garter snakes. Snake drift fence traps, which consisted of 4-5 m draft fences leading to funnel traps, and set in shallow water, were difficult to use because water levels dropped or rose rapidly in some seasons, and re-setting these traps is time-intensive. They were moderately effective at catching garter snakes, and sometimes functioned as terrestrial, stream-edge traps, catching terrestrial reptiles. Overall, the traps were most effective for turtles (hoop nets), garter snakes (all traps), and ranid frog larvae (hoop nets and minnow traps). For other taxa, the traps we used were not worth the effort.

For the Mexican Garter Snake, as previously noted, capture success with the aquatic snake traps was low. Using other trapping types, overall success was somewhat better. Collapsible net minnow traps had the highest capture success, but sample sizes were low. These and the customized hoop nets are the most promising sampling methods for garter snakes at Las Ciénegas, as they are relatively easy to handle. They also worked well for sampling ranid frogs, turtles, fishes, and aquatic invertebrates.

Table 2. Capture rates per trap-day for the Bullfrog and Mexican Garter Snake in different kinds of traps at Las Ciénegas during 2002-3.

Species	Metal Minnow Trap	Net Minnow Trap	Hoop Net	Snake Trap
Trap-days	228	58	42	163
Rana catesbeiana	0.022	0.086	0.452	0.000
Thamnophis eques	0.026	0.103	0.071	0.037

For bullfrog removal, the most effective method was gigging. However, shooting is generally more certain, though less desirable in other ways. In some situations, especially where removing wary individuals, or where rapid, more certain removal is necessary, shooting with .22 caliber rifle or dust-shot pistol is preferred. Survey for bullfrog larvae at Las Cienegas was most effective with the custom-made hoop nets.

Table 3. Observations of amphibians and reptiles at Las Cienegas in 2002-3, broken down by method used.

Species Acronym	Metal Minnow Trap	Net Minnow Trap	Hoop Net	Snake Trap	Road	Other	Gig	Gun	Other Audiovisual Search	Total
BUAL					1				2	3
BUPU									1	1
CNBU				3	1				49	53
CNSO				2					54	56
CNTI									1	1
CNUN				10					612	622
COTE					1				9	10
COVA									2	2
CRAT					1				13	14
CRCO					4				0	4
CRSC					2				2	4
DIPU				1	1				1	3
ELKI									6	6
HENA					1				0	1
HESU					1				2	3
HOMA					4				30	34
HYTO					1				2	3
KISO	8	7	77	4		6			264	366
LAGE									1	1
MABI									5	5
MAFL					3	1			2	6
PHSO					4				5	9
PIME					2	1			6	9
RACA	5	5	19			4	123	17	169	342
RACH	1					3			152	156
SAHE					3				0	3
SCCL									36	36
SCCO					1				6	7
SCSL									26	26
SCUN				3					33	36
TAHO									2	2
TEOR						4			1	5
THEQ	6	6	3	6					8	29
THMA									1	1
UROR									189	189
Total	20	18	99	29	31	19	123	17	1692	2048

Discussion

Community Structure

As noted above, ten or eleven species of amphibians and reptiles with riparian associations are known from Las Cienegas (Western Box Turtle, Giant Spotted Whiptail, Madrean Alligator Lizard, Clark's Spiny Lizard, Eastern Fence Lizard, Slevin's Bunchgrass Lizard, Sonoran Whipsnake, Ring-necked Snake, Common Kingsnake, Southwestern Black-headed Snake, probably the Sonoran Desert Toad should also be included), plus seven aquatic species (American Bullfrog, Chiricahua Leopard Frog, Lowland Leopard Frog, Sonoran Mud Turtle, Mexican Garter Snake, Checkered Garter Snake, and Black-necked Garter Snake. Among these 18, only the Sonoran Whipsnake, Common Kingsnake, Southwestern Black-headed Snake, and Sonoran Desert Toad would be likely to have substantial populations without the ciénega, stream, and sacaton bottomlands. However, the community structure in these relatively mesic lowlands is not entirely dominated by the locally riparian-obligate or preferentially riparian species.

About 24 species comprise the core of the cienega herpetofaunal assemblage (Table 4). Along the stream, the most prominent species were the Sonoran Mud Turtle, American Bullfrog, and Mexican Garter Snake. The terrestrial environs of the ciénega bottom were most conspicuously occupied by 10 lizard species and 4 snake species: 3 whiptails, 3 spiny lizards, the Tree Lizard, Lesser Earless Lizard, Madrean Alligator Lizard, and, in certain spots, the Greater Earless Lizard; and Sonoran Whipsnake, Western Diamondback, Gopher Snake, and Ring-necked Snake. These 17 species are currently the primary known herpetofaunal occupants of the cienega, and to them should be added the 2 leopard frogs and 5 other snake species (Mohave Rattlesnake, Coachwhip, Checkered Garter Snake, Southwestern Black-headed Snake, and Common Kingsnake) for a core of about 24 species. Species may likely be added by future work, but not many.

Not only is the lizard assemblage diverse at Las Ciénegas, but species abundances were also apparently high. The lizard assemblage is remarkable for the extensive participation of 7 highly specialized and regionally endemic taxa (all 6 whiptail and spiny lizards, and the alligator lizard), while only 3 of the snakes fall into such a category (Mexican Garter Snake, Sonoran Whipsnake, and Regal Ring-necked Snake). As at San Bernardino NWR, the snake fauna has a strong representation of widespread North American Desert species. Among 4 riparian areas examined using museum and field data, Las Ciénegas and Ciénega Creek County Preserve were most similar to San Bernardino NWR and least similar to the canyon riparian herpetofauna at Leslie Canyon NWR, with the similarity coefficient for a historic Tucson lowland riparian assemblage being closer to Las Ciénegas than to the other sites (Rosen et al. *manuscript*). There thus appears to be a somewhat homogeneous lowland riparian herpetofauna, which was originally most diverse in the Santa Cruz Valley but now is best represented at Ciénega Creek, especially at Las Ciénegas.

Population Interactions

Although we did not make systematic research efforts focused on population interactions, some comments concerning the ecology of the aquatic-riparian system may be useful. The food web in Ciénega Creek has raptors, herons, and raccoons at the top, with garter snakes at a slightly lower trophic position. These predators feed on frogs, fishes, and lizards, and some mice; the basal portions of the food web have terrestrial (insects, seeds, and primarily foliage production) and aquatic (fish and frogs that feed on insects and smaller fish) components.

Many of the aquatic animals have complex life cycles placing them at more than one trophic level and in two divergent parts of the food web. For example, tadpoles graze on algae and other microorganisms, the base of the food web, and they may then be preyed upon by aquatic larvae of such insects as dragonflies, which may transform into predatory adults in the terrestrial food web, or may be preyed upon by metamorphosed frogs. This part of the food web is probably more complicated, in terms of loops and divergences, than the upper portion. Among terrestrial and semi-aquatic vertebrates, there may be surprising examples of predation, such as snakes that may eat nestlings of hawk species that prey heavily on these same snake species; but these are exceptional observations, whereas the complexity among amphibians, fishes, and aquatic invertebrates occurs at energetically important points throughout whole parts of the web.

Two important concepts for understanding the workings of the ciénega and stream food web are indirect effects and apparent competition. Indirect effects are probably important throughout most or all food webs. They occur when, for example, one species harms its apparent competitor by supporting predator populations that create predation pressure it can stand better than its apparent competitor. This can lead its apparent competitor into a predation-induced decline, rather than one resulting from competition.

Something like this could occur in the interaction between bullfrogs and leopard frogs. Although bullfrog tadpoles may have low survivorship in invertebrate-rich environments, their large numbers and susceptibility to invertebrate predation may allow large populations of tadpole-eating insects to flourish, making it difficult for leopard frog tadpoles to survive. Other indirect interactions are also likely. Chubs, like bluegill sunfish, are highly insectivorous, and appear to eat leopard frog tadpoles but not bullfrog tadpoles; thus, by eating the predators of the bullfrog tadpoles, but not the tadpoles, they may facilitate bullfrog population expansion and increase the impact on leopard frogs. Additional indirect interactions are also possible. For example, predation on small invertebrates by small fish like dace or topminnows could truncate the invertebrate food web, again possibly favoring bullfrogs. These ideas require further investigation.

Food web interactions may also critically affect the abundance of the Mexican Garter Snake. While predation by bullfrogs on this snake is believed to be an important problem, at least at high bullfrog density (Rosen and Schwalbe 1995, 2002), other interactions may also be important. For example, by predation, larval competition or apparent competition, or by serving as a disease vector (Bradley et. al 2002), bullfrogs may reduce or eliminate leopard frog populations, a staple for the garter snake. The snakes may then disappear from areas lacking its secondary prey, native fishes, or rely on young bullfrogs as prey in a precarious ecological dynamic with a species that preys heavily on the young snakes. It is thus of interest that we confirmed the persistence of the Mexican Garter Snake in reaches of Ciénega Creek where bullfrogs are rare and the only abundant prey are probably fish, supplemented by lizards, mice, and toads.

Where there are bullfrogs, the Checkered Garter Snake may become the more successful garter snake, as described above, by avoiding bullfrog predation as a juvenile. The Checkered Garter Snake population may then support garter snake predators, including bullfrogs and many other, native species, which may accelerate the decline of the Mexican Garter Snake by apparent competition. Such a mechanism is not as abstruse as it might sound: in some areas with bullfrogs, such as San Bernardino NWR, young bullfrogs are so abundant as prey that growth rates and ultimate size reached in the Mexican Garter Snake are very high, yet the population declined to apparent extirpation (Rosen et al. 2002) while the Checkered Garter Snake flourished.

This discussion should serve to illustrate that conservation of the Southwestern aquatic biota may not be successful with a series of focused, single-species approaches. If that is correct, successful conservation will require good single-species knowledge brought into an experimental-managerial framework for multiple species. It is unlikely that these problems can be solved without an interaction between adaptive management and controlled experimental research, with an anchor in conceptually guided comparative field observations.

Causes of Decline

Leopard Frogs. The decline of the leopard frogs at Las Ciénegas since 1975 is clear based on evidence from John Frost's notes, observations in 1984-1987 by P. Rosen, from 1990-2003 by J. and K. Simms, and our more recent observations beginning in 1996. Two species of leopard frogs were reasonably abundant and easily observed in the area in 1975-6, and leopard frogs were still found from Mattie Canyon to the Headwaters reach during the mid-1980's to mid-1990's, though in decreasing frequency and in progressively fewer areas. By the 21st century, observations had become restricted to three sites, with only a single one appearing to support a small reproducing population.

Leopard frog populations can fluctuate with poorly understood variation in recruitment, and also likely respond to drought. It is not impossible that a natural rebound will occur at Las Ciénegas, especially since we have not identified any obvious, powerful causes of decline. However, there are ecological problems; the observed decline has apparently been ongoing for 30 years under ecological conditions like those that exist today; and it appears more likely than not that leopard frogs will be extirpated without management attention.

As at Las Ciénegas, leopard frogs have declined in abundance in the County Preserve reaches, downstream of Interstate Highway 10 (Fig. 2). This decline occurred during years when we made repeated observations of winter mortality from chytrid fungus disease (chytridiomycosis); it has also occurred during a progressive drought continuing from a high water mark in 1977-1984, during which pools contracted, grazing was removed, improving streamside vegetation characteristics for frogs, and whole reaches that were formerly heavily populated by frogs have become dry or too shallow and structurally simple to support many frogs. Bullfrogs were seen this reach for the first time at the end of the 1990's, though they may have contacted the leopard frog population, and transmitted chytridiomycosis to it, much earlier.

Based on the reduction in water, and associated change in habitat availability, we must conclude that drought conditions are playing a direct role in population decline in the County Preserve. Despite drought, there remains at least 1.8 mi (ca. 3 km) of high quality habitat, yet frogs are seen with remarkable infrequency there. Garter snakes are uncommon, and although small mammals and herons are abundant, as in earlier decades, the available cover should allow the frog population to thrive despite these predators. The Lowland Leopard Frog population goes through an abundance peak going into fall, as spring tadpoles grow to adult size; population size is reduced to low levels during the winter, the time when disease has been most evident. The disease appears to be the novel factor, and the best available explanation is that the decline has progressed beyond the population's natural drought response because of the disease.

We have few observations of Lowland Leopard Frogs at Las Ciénegas, as summarized above. We would expect that the Lowland Leopard Frog was more abundant in rockier, more scouring reach of Ciénega Creek near The Narrows than in the upper reaches, and that it may have occupied semi-perennial reaches in Mattie Canyon and near Ciénega Ranch during years of increased flow. The only readily available explanation for the species' disappearance from Las Ciénegas is disease. This is inferred from what we know downstream in County Preserve, and from observations by J. Simms of dead frogs during fall fish sampling in The Narrows and nearby reaches.

The Chiricahua Leopard Frog is of great interest at Las Ciénegas. It represents the only remaining lowland riparian population of a species that was probably once most abundant in such settings, and it is the last remaining ciénega population known except for a marginal one in O'Donnell Creek (Rosen and Schwalbe 2001, 2002). This species remained in Gardner Canyon in the Santa Rita Mountains at least to 1994 (PCR, unpublished observations), and probably to the present, although it is not abundant there. Thus, it is close to regional extirpation in an area where Frost found it abundant in many places, and Hale and others (1983, 1988) also reported healthy populations.

Causes of decline in this area have not been carefully investigated, but some general information is available. By 1975-6, Frost noted the species' absence from what he viewed as optimal habitat at Babocomari, and this can be attributed to the numerous non-native fishes established early at that site. In 1985, I found this leopard frog species at Elgin in Babocomari River pools that remained perennial, and also supported longfin dace, during that wetter era; and in grassland ponds on the Elgin Research Ranch at that time. As drought spread, these areas dried, and suitably perennial waters were reduced to those occupied by harmful non-native fish, especially green sunfish, largemouth bass, and black bullheads. By 1987-8, this trend was already clear. This aspect of the decline of the species reflects the effects of natural drought superimposed on the gradual expansion of harmful exotics from larger core sites into a periphery of progressively smaller and less perennial waters.

Although there is no information on this in the Las Ciénegas region, Frost (*unpublished notes*) worked in at least two stock ponds in the Gardner Canyon drainage near State Route 83, both with successful breeding. These populations were probably extirpated by the processes seen in the Babocomari-Sonoita Grasslands area, and this has probably occurred through much of the country near the Santa Ritas. Bullfrogs arrived in the region and spread, probably during 1985-2000, and although they have not been found in abundance at Las Ciénegas, they may have occupied stock ponds and there affected the Chiricahua Leopard Frog. Such stock ponds, which probably contributed migrating juvenile leopard frogs to the frog-scape, now contribute bullfrogs, or nothing.

The problem is to identify what may have happened to the Chiricahua Leopard Frog population at Las Ciénegas, and to determine why it remains so small. There would appear to be adequate vegetation in Ciénega Creek to protect leopard frog tadpoles from predation by chubs. Bullfrogs seem too uncommon to affect leopard frogs in the stream by predation or by larval competition. We have not recorded chytridiomycosis at Las Ciénegas, although a reasonable hypothesis is that it previously afflicted leopard frog populations at the site, and either burned out for lack of vectors, failed to reach Empire Gulch Spring, or is tolerated by the Chiricahua Leopard Frog to some degree, allowing frogs to persist at relatively optimal sites. Only by careful cool season monitoring of leopard frogs to determine if the disease is present, and by applying new methods of testing on leopard frogs and bullfrogs to determine if the pathogen is present without disease, can we clarify any of this.

Bullfrogs at Las Ciénegas could possibly have significant impacts on the Chiricahua Leopard Frog despite the low population densities. They occupy the larger pools, which are probably naturally marginal for leopard frogs because large, predatory Gila chubs are abundant in them. Although bullfrog larvae are not abundant, a single clutch of bullfrog eggs normally produces 10-20,000 of them, and these may significantly increase the load of tadpole predators in local areas. Similarly, at Cinco Ponds, irregular breeding by bullfrogs, although not producing large numbers of metamorphosing juveniles, may make the predatory environment unfavorable for tadpoles. This may be a strong effect if, as we suspect, bullfrog tadpoles are highly susceptible to insect predation. Whereas ciénegas sites might naturally support modest numbers of leopard frog tadpoles, with such increased predation pressure they may support fewer, or none. As with disease, these are hypotheses that can only be evaluated with rigorous testing.

Although bullfrogs are uncommon at Las Ciénegas compared to places like Arivaca, San Pedro River, San Bernardino NWR, and many others in southeastern Arizona, significant numbers were found. For example, 46 bullfrogs large enough to eat juvenile and at least small adult Chiricahua Leopard Frogs were recorded at the Springwater confluence reach of Ciénega Creek in 2002-3, and 157 were recorded in Cinco Ponds. In early summer 2002, Chiricahua Leopard Frogs were heard calling in that part of Ciénega Creek, but there was no evidence of successful reproduction, nor of persistence into 2003. In summer 2003, a handful of metamorph Chiricahua Leopard Frogs were found at Cinco Ponds, where they almost certainly grew as tadpoles that year, but no adults were found, and we have not yet found the species there in 2004. On top of the larval predation impacts, hypothesized above, predation by bullfrogs on leopard frogs could be a determining factor in preventing re-establishment of abundant leopard frog populations in Ciénega Creek and Cinco Ponds. Careful study and observations under adaptive management would be needed to clarify this problem.

Mexican Garter Snake. This species has also apparently declined over the period of observation from 1985-2003, although currently we have too little knowledge to determine what happened. Intensive studies were done at Findley Tank at Elgin Research Ranch, where largemouth bass were removed and Quitobaquito pupfish were introduced by a University of Arizona graduate student ca. 1979. During 1986-7 pupfish were abundant, and were important prey for Mexican Garter Snakes there, which occurred in a dense population estimated at 95 snakes in 0.2 ha. From 1985-6, Chiricahua Leopard Frogs and their larvae were present, though not abundant, and these were also important prey for the snakes, especially for larger snakes. The decline, and then disappearance of leopard frogs at Findley Tank correlated closely with a major decline in the abundance of juvenile garter snakes, and this has apparently led to the markedly reduced, adult-dominated population found during re-census in 2000 (Rosen and Schwalbe 2001, 2002).

Similarly, in the 1950's, the Mexican Garter Snake was found in high density at Babocomari Ranch (R. Bezy, *pers. comm*. 2001), but by 1985-7 they were rare there, and in a 2000 survey they were not found. This observation may also be related to the elimination of leopard frogs at Babocomari, which presumably occurred with the introduction and spread of predatory non-native fish. By 2000, bullfrogs were established at Babocomari, and it will be of some interest to see if the snake population persists and stabilizes there by preying on bullfrogs and fish. A similar dynamic might be ongoing at Las Ciénegas.

With the decline of leopard frogs at Las Ciénegas, it is perhaps not surprising that a dependant species, the Mexican Garter Snake, has also declined. Whether this snake species will continue to decline, or will reach some stable interaction with the bullfrog population, remains unknown.

Recommendations

We will offer recommendations under four categories, interpretation for the public, research needs, adaptive management, and conservation and monitoring methods for ranid frogs.

Interpretation. Las Ciénegas is the outstanding example of the original lowland riparian environment for the Tucson region, as well as the best example of lowland aquatic and ciénega habitat in the Southwest – at least in the United States. The aquatic and riparian herpetofaunal assemblage is diverse and interesting. Nowhere else is there an intact lowland fish assemblage. Birds, occurring in ciénega, bosque, and grassland are also spectacularly diverse and abundant, as undoubtedly are other groups of organisms. While the site is vulnerable to degradation by careless human behavior, it should also have a strong constituency that will bring resources and active protection. The fine diversity and interesting species, and the uniqueness of the area, should form the basis for one or more, well-produced, colorful, relatively sophisticated pamphlet- or booklet-sized productions to be distributed through selected outlets. The constituency, or target audience, should consist of thoughtful ranchers and other local residents, environmentalists, birdwatchers, botanists, and business and political leaders with a genuine interest in nature. One objective, in addition to, or as part of building this constituency, should be to armor the site against exotic fish or crayfish introductions, and to encourage the formation of a local plan to eliminate the bullfrog. Although a high level of text material may be appropriate, anything less than a high level of color illustration would not.

Research. Key research questions for the amphibian and reptile component at Las Ciénegas have to do with (1) the overall species assemblage, (2) causes of decline and rarity of selected aquatic species, and (3) population dynamics and methods of removal for the bullfrog.

(1) We have established a solid baseline checklist for the herpetofauna of the area, but much remains to be learned:
   a. For the list to grow toward completeness, extensive survey should be coupled to future intensive or targeted herpetological work whenever feasible.
   b. The semi-desert grassland uplands, and their relationship to the abundance of summer breeding amphibians there and on the sacaton bottoms, needs to be addressed by further survey.
   c. Certain riparian species need further study to determine distribution and abundance, notably the Desert Box Turtle, Madrean Alligator Lizard, and Slevin's Bunchgrass Lizard.

(2) To understand the problems and pursue adaptive management, especially for the Chiricahua Leopard Frog, we need to understand its causes of decline:
   a. Wintertime and PCR-based sampling studies are needed to determine if the chytrid pathogen *Batrachochytrium dendrobatidis* is present and if it is causing the disease chytridiomycosis. Both leopard frogs and bullfrogs should be tested at Las Ciénegas.
   b. If possible, support for study of the disease and its epidemiology should be secured for at least one population of each leopard frog that is persisting with the disease (Lowland Leopard Frog: County Preserve, Hot Springs Canyon, Aravaipa Canyon; Chiricahua Leopard Frog: Sycamore Canyon in Pajarito Mountains, Leslie Canyon NWR). Such a study might also look

at the Chiricahua Leopard Frog and Tarahumara Frog in the Santa Rita Mountains, where the latter is currently being re-established.

c. The interaction of bullfrogs and leopard frogs that is mediated at the larval level through fish and invertebrates should be evaluated by a combined field-laboratory-microcosm-mesocosm-adaptive management study design to determine the strength of impacts of these interactions. The study has a one-year seed funding currently available.
d. Population monitoring on a regular basis, with enough depth to understand age-class and life-stage structure that reflect population dynamics are needed for the most imperiled species, the Chiricahua and Lowland Leopard Frogs and the Mexican Garter Snake; and for interacting species, specifically the American Bullfrog and Checkered Garter Snake.
e. A population estimate should be obtained of the Mexican Garter Snake in at least one section of the creek, using mark-recapture methods.
f. A radio-telemetry study of the Mexican Garter Snake should be conducted to determine microhabitat and macrohabitat use, thermal ecology, activity patterns, and habitat used for hibernation.
g. The Lowland Leopard Frog populations in Wakefield Canyon should be re-surveyed and their status established. The species should be sought in The Narrows.

Adaptive Management. Adaptive management is stressed because there are uncertainties in our knowledge. The ecological problems we face are somewhat complicated. We will gain the most knowledge, and achieve the best success by testing our best conservation hypotheses with management, learning from the results, and moving forward with incrementally improved understanding.

The first objectives of adaptive management should be to (1) secure the Chiricahua Leopard Frog, (2) establish the distribution of bullfrogs in the Empire Valley region and remove outlying source populations, and then (3) eliminate bullfrogs from Las Ciénegas.

(1) The Chiricahua Leopard Frog population should be secured by creating a screened-in or fenced, small pond on the Las Ciénegas site, and/or at an off-site, completely protected site. The facility can be partially modeled after existing facilities. It can serve to provide tadpoles for research and for release to the wild. The facility should be populated with part of an egg mass from Empire Gulch Spring, which should be found during monitoring there, or from elsewhere at Las Ciénegas if eggs are found. Small tadpoles could also be used to found the population if they are located in abundance in the wild. At a minimum, small portions ($\leq$ 10 %) of two eggs masses, or 10 tadpoles, should be used to start the population, and occasional additions of eggs and tadpoles should be done to expand the gene pool. If this cannot be accomplished satisfactorily from Las Ciénegas populations, material from Gardner Canyon could be substituted.

(2) Stock ponds should be surveyed for bullfrogs in the valley and bajadas below The Narrows.

(3) Negotiations to purchase or manage Northwest Reservoir, where bullfrogs (and non-native fish) are known, should be actively pursued. The management of Road Canyon Tank with annual drying to prevent bullfrog reproduction should be continued, and this applies to similar artificial pond situations that may be discovered.

(4) Eliminate bullfrogs from Las Ciénegas by:
   a. using targeted removals at Cinco Ponds and at selected reaches of the stream,
   b. using biological control information from the research program to minimize the reproductive success of bullfrogs in the removal areas.

(5) Supplement the population of the Chiricahua Leopard Frog at Las Ciénegas using releases from the protected population as feasible and appropriate, and monitor results in relation to bullfrog removals and habitat types and conditions.

Monitoring Ranid Frogs. The Chiricahua Leopard Frog population at Las Cienegas should be observed at least 4 times per year until management has succeeded in bringing from the brink of extinction. There should be 4 visits/year to Empire Gulch Spring to count frogs at night by carefully stalking along the reach from the spring to the end of flow or at least to the main road crossing. Extensive surveys should be conducted twice per year, by stalking at night, at least at the sites along the stream where leopard frogs were found in 2002-3. Cinco Ponds should be visited twice per year looking for frogs, and dipnetting for tadpoles by wading and/or trapping during the daytime. These visits should all be during the warm season from April through September.

Initially, a primary objective of this monitoring should be to find eggs or tadpoles that can be used to population the refugia described above. This may require more visits than necessary to acquire the minimum number of necessary monitoring counts. These additional searches for eggs should be conducted during days when the monitoring personnel are on-site for other reasons, such as surveying at the stream, at Cinco Ponds, or for other related work. Once the refugia are stocked with eggs or tadpoles, it must be monitored closely – two or more times/week at first, and regularly at least once per week to ensure that no problems develop. An off-site refugium at a home or workplace that can be constantly monitored should also be considered.

As a second high priority, fall and wintertime monitoring to look for evidence of disease should be conducted, with 3 visits per years starting at the first cold snap, then in early January or late December, and again in mid-late February. At any time that frogs or large tadpoles are handled, they should be swabbed to collect samples for PCR analysis for presence of the chytrid pathogen. These samples are to be sent to a laboratory for analysis.

At the same time, Bullfrog populations should also be monitored by (1) counting frogs observed, (2) observing and capturing tadpoles, and (3) listening for and locating breeding choruses. Bullfrog removals should continue if significant effort can be expended with focus on specific target areas. A subset of Bullfrogs taken should be tested for the chytrid pathogen.

During monitoring, in addition to date, time, and other parameters to be recorded using a Chiricahua Leopard Frog survey form supplied by USFWS and AGFD, it is especially important that monitoring personnel record sizes of observed tadpoles and frogs. Surveyed areas should be recorded digitally, either as routes on GPS units or by tracing them on digital topographic maps. Observation points for ranid frogs should always be recorded as waypoints in the field using a GPS unit. Annotations should be recorded evaluating survey conditions to ensure that data are interpreted properly.

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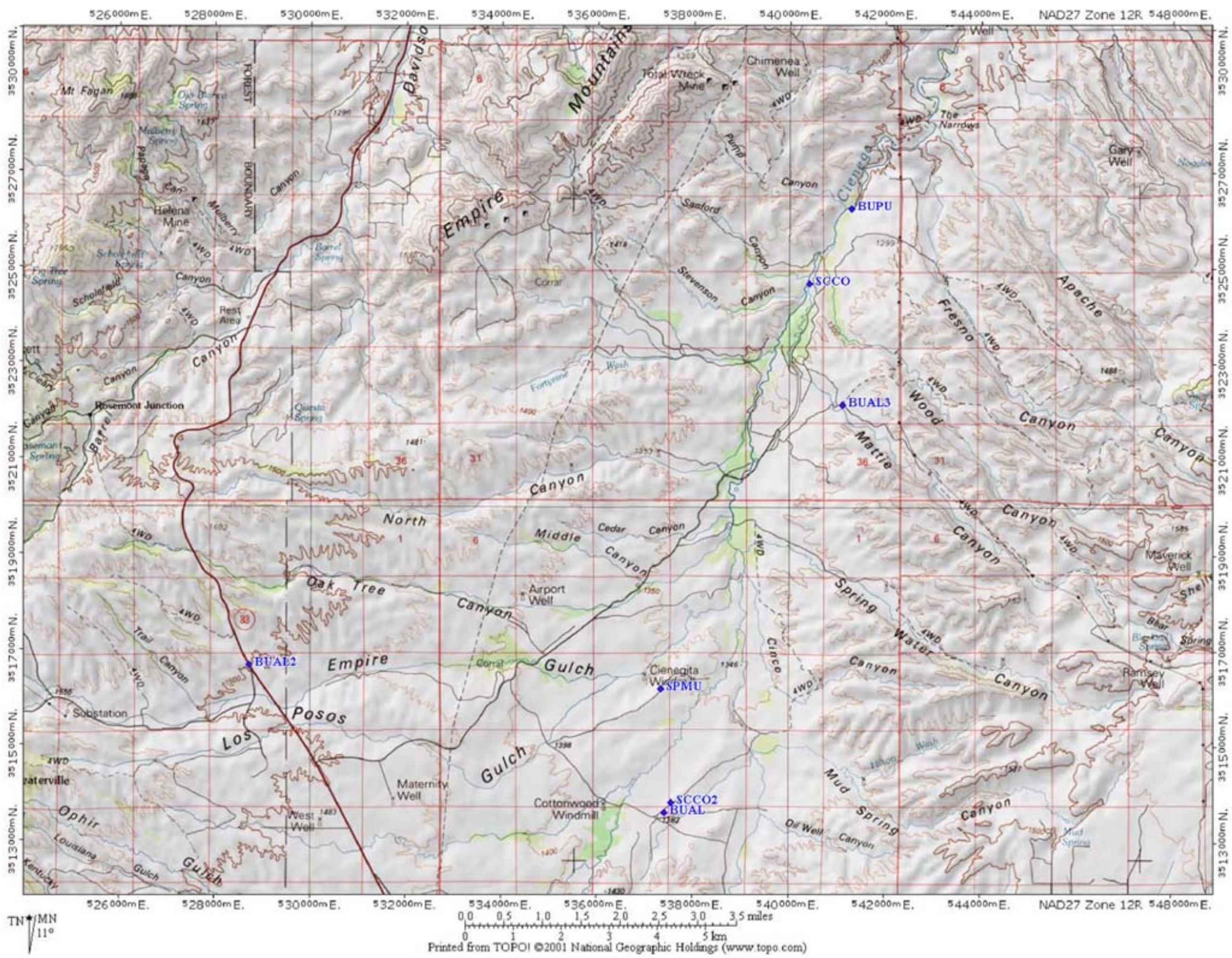
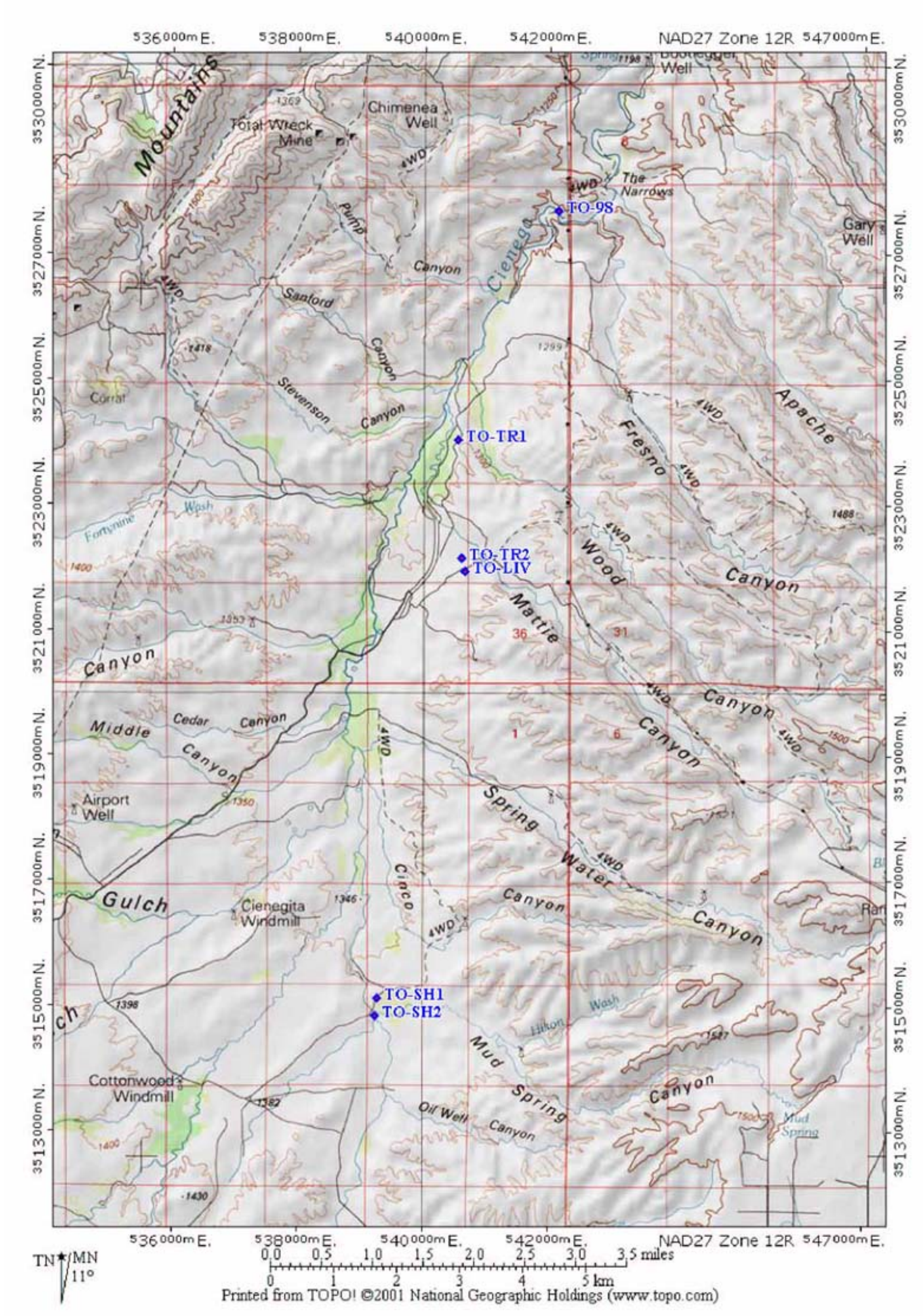
Table 4. Amphibian and reptile species and habitat associations at Las Cienegas National Conservation Area, Pima County, Arizona. Species marked with an asterisk (*) are expected to occur based on nearby records on Sate Route 83 or in Sonoita Grasslands. Classification as Riparian Obligate, Preferentially Riparian (or Riparian-Associated), and Riparian-included follows Rosen et al. (*submitted*). Macrohabitat categories are estimated based on local observations. Data are for 1985-2003.

SPECIES	Las Cienegas TOTAL observations	Riparian category	Macrohabitat category
Taxa Found in Riparian Environs			
Anurans			
Rana catesbeiana (Exotic)	374	Locally Obligate	Aquatic
Rana chiricahuensis	308	Locally Obligate	Aquatic
Rana yavapaiensis	16	Locally Obligate	Aquatic
Scaphiopus couchii	9	Riparian-included	Semi-desert Grassland
Bufo alvarius	2	Preferentially Riparian	Bottomland
Bufo punctatus	1	Riparian-included	Semi-desert Grassland
Spea multiplicata	1	Riparian-included	Semi-desert Grassland
Turtles			
Kinosternon sonoriense	400	Locally Obligate	Aquatic
Terrapene ornata	6	Locally Obligate	Bottomland
Lizards			
Cnemidophorus uniparens	733	Riparian-included	Widespread
Urosaurus ornatus	208	Riparian-included	Widespread
Holbrookia maculata	62	Riparian-included	Widespread
Cnemidophorus burti	61	Locally Obligate	Riparian
Cnemidophorus sonorae	61	Riparian-included	Widespread
Sceloporus clarkii	46	Preferentially Riparian	Riparian
Sceloporus undulatus (cowlesi)	41	Locally Obligate	Riparian
Sceloporus slevini (scalaris)	26	Preferentially Riparian	Bottomland
Cophosaurus texanus	13	Riparian-included	Widespread
Elgaria kingii	8	Locally Obligate	Riparian
Eumeces obsoletus	*	Riparian-included	Grassland
Snakes			
Thamnophis eques	39	Locally Obligate	Aquatic
Crotalus atrox	15	Riparian-included	Widespread
Pituophis catenifer	8	Riparian-included	Widespread
Masticophis bilineatus	7	Preferentially Riparian	Riparian
Crotalus scutulatus	4	Riparian-included	Widespread
Diadophis punctatus	3	Locally Obligate	Riparian
Masticophis flagellum	2	Riparian-included	Semi-desert Grassland
Tantilla hobartsmithi	2	Preferentially Riparian	Widespread
Lampropeltis getula	1	Preferentially Riparian	Widespread
Thamnophis marcianus	1	Preferentially Riparian	Aquatic
Thamnophis cyrtopsis	1	Preferentially Riparian	Aquatic

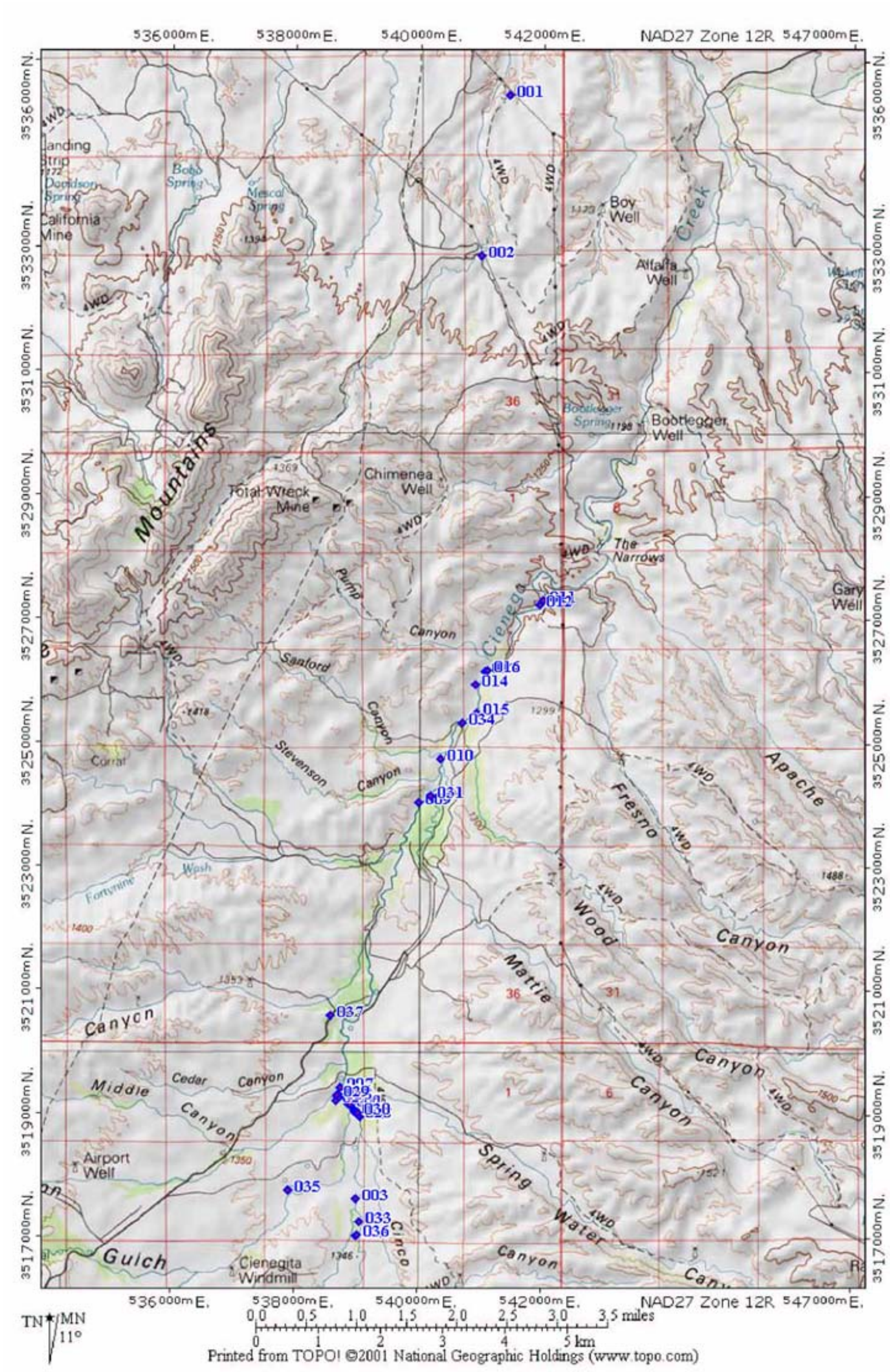
Rhinocheilus lecontei	1	Riparian-included	Widespread
Upland Taxa			
Lizards			
Phrynosoma solare	8	Upland, Non-riparian	Semi-desert Grassland
Crotaphytus collaris	4	Upland, Non-riparian	Semi-desert Grassland
Heloderma suspectum	2	Upland, Non-riparian	Semi-desert Grassland
Coleonyx variegatus	1	Upland, Non-riparian	Semi-desert Grassland
Cnemidophorus tigris	*	Upland, Non-riparian	Desertscrub
Sceloporus magister	*	Upland, Non-riparian	Desertscrub
Snakes			
Hypsiglena torquata	3	Upland, Non-riparian	Widespread
Salvadora hexalepis	2	Upland, Non-riparian	Semi-desert Grassland
Heterodon nasicus	1	Upland, Non-riparian	Grassland
Gyalopian canum	*	Upland, Non-riparian	Semi-desert Grassland
Leptotyphlops humilis	*	Upland, Non-riparian	Semi-desert Grassland
Micruroides euryxanthus	*	Upland, Non-riparian	Thornscrub
Salvadora grahamiae	*	Upland, Non-riparian	Woodland
Sonora semiannulata	*	Upland, Non-riparian	Grassland
TOTAL	2,482		
Potential Species Total	46		
Species Total	38		



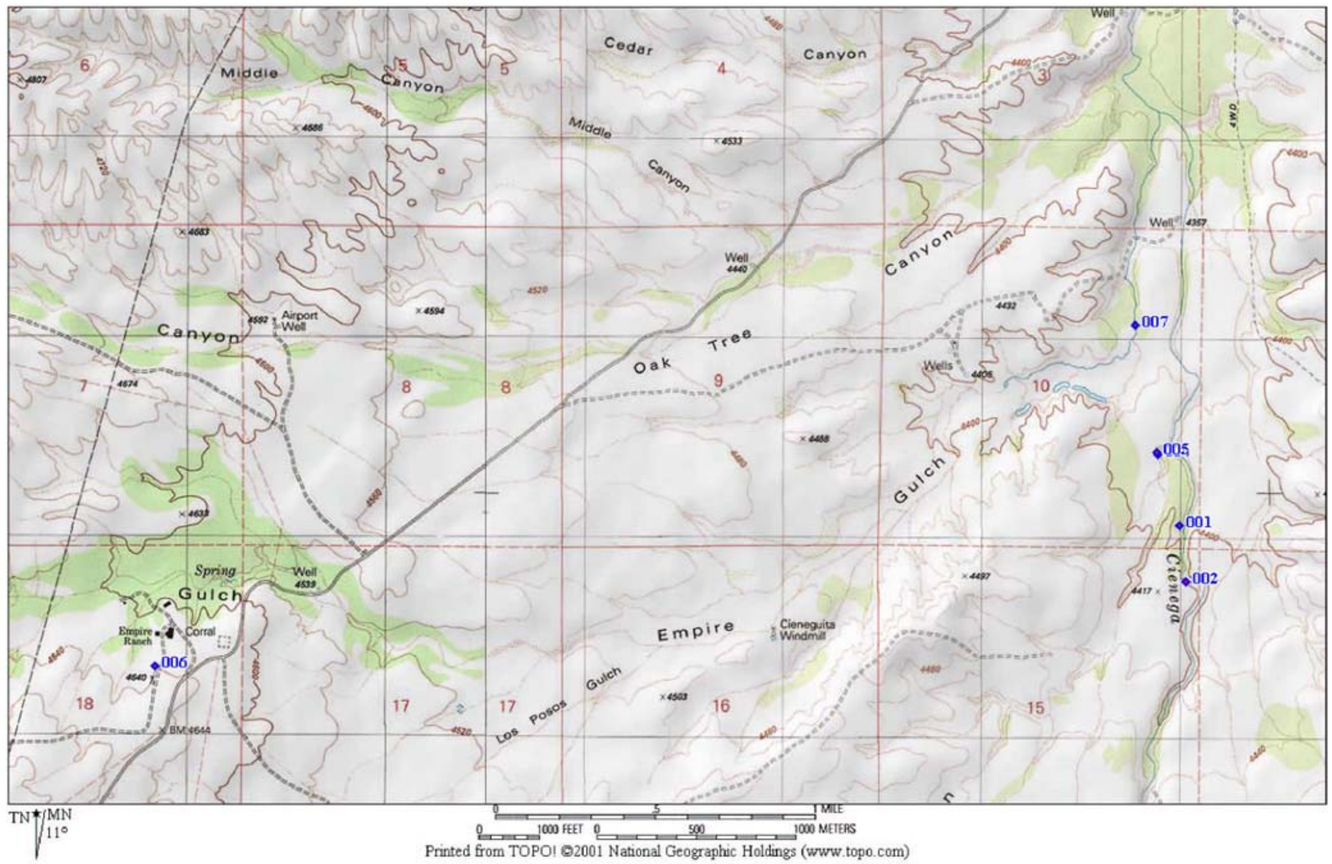
Map 1. Distribution of toads (BUAL – Sonoran Desert Toad *Bufo alvarius*, BUPU – Red-spotted Toad *Bufo punctatus*, SCCO – Couch's Spadefoot *Scaphiopus couchii*, SPMU – Mexican Spadefoot *Spea multiplicata*) at Las Cienegas recorded during 2002-3.



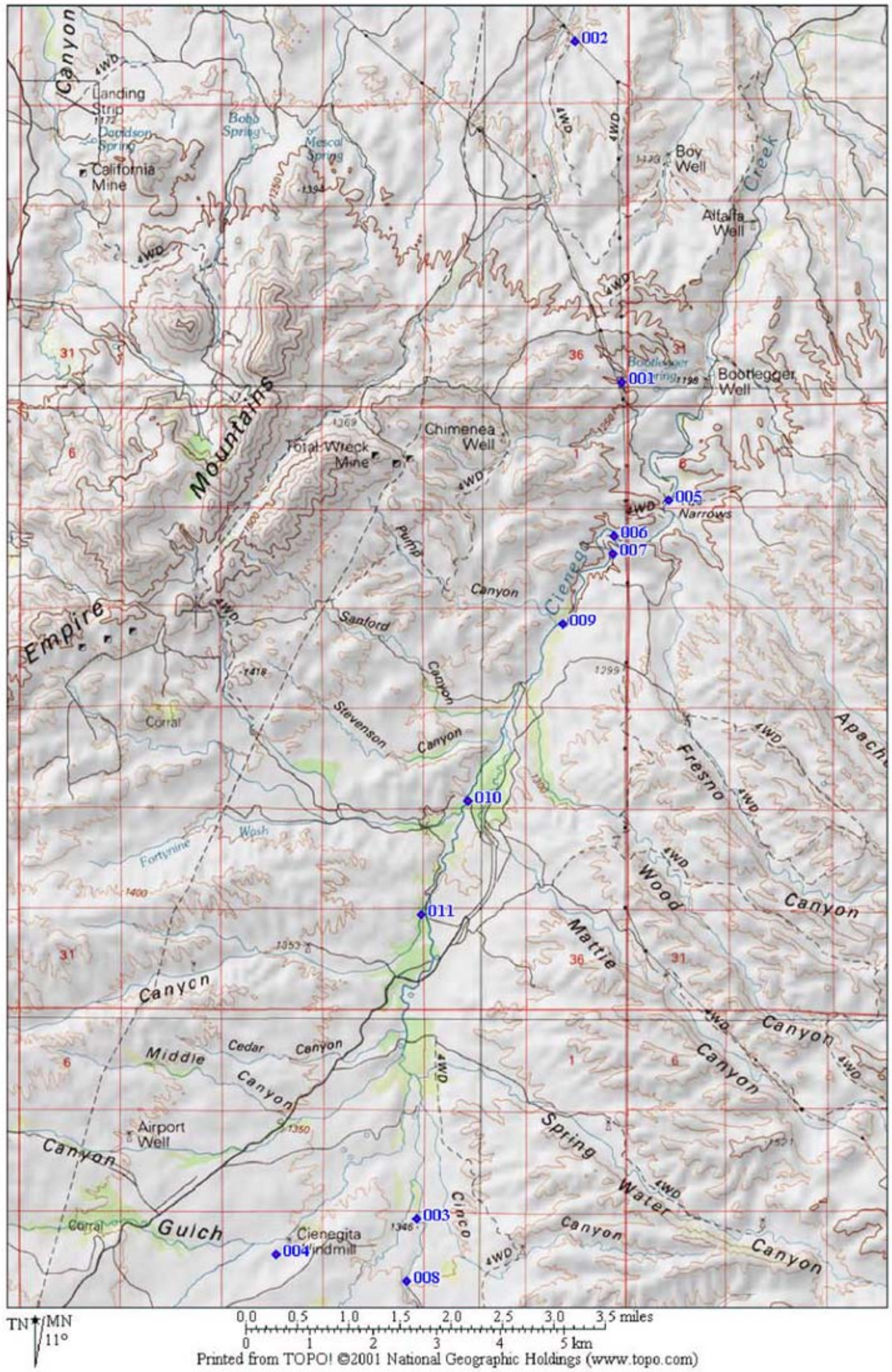
Map 2. Distribution of the Desert Box Turtle (*Terrapene ornata luteola*) observed as Las Cienegas during 2002-3.



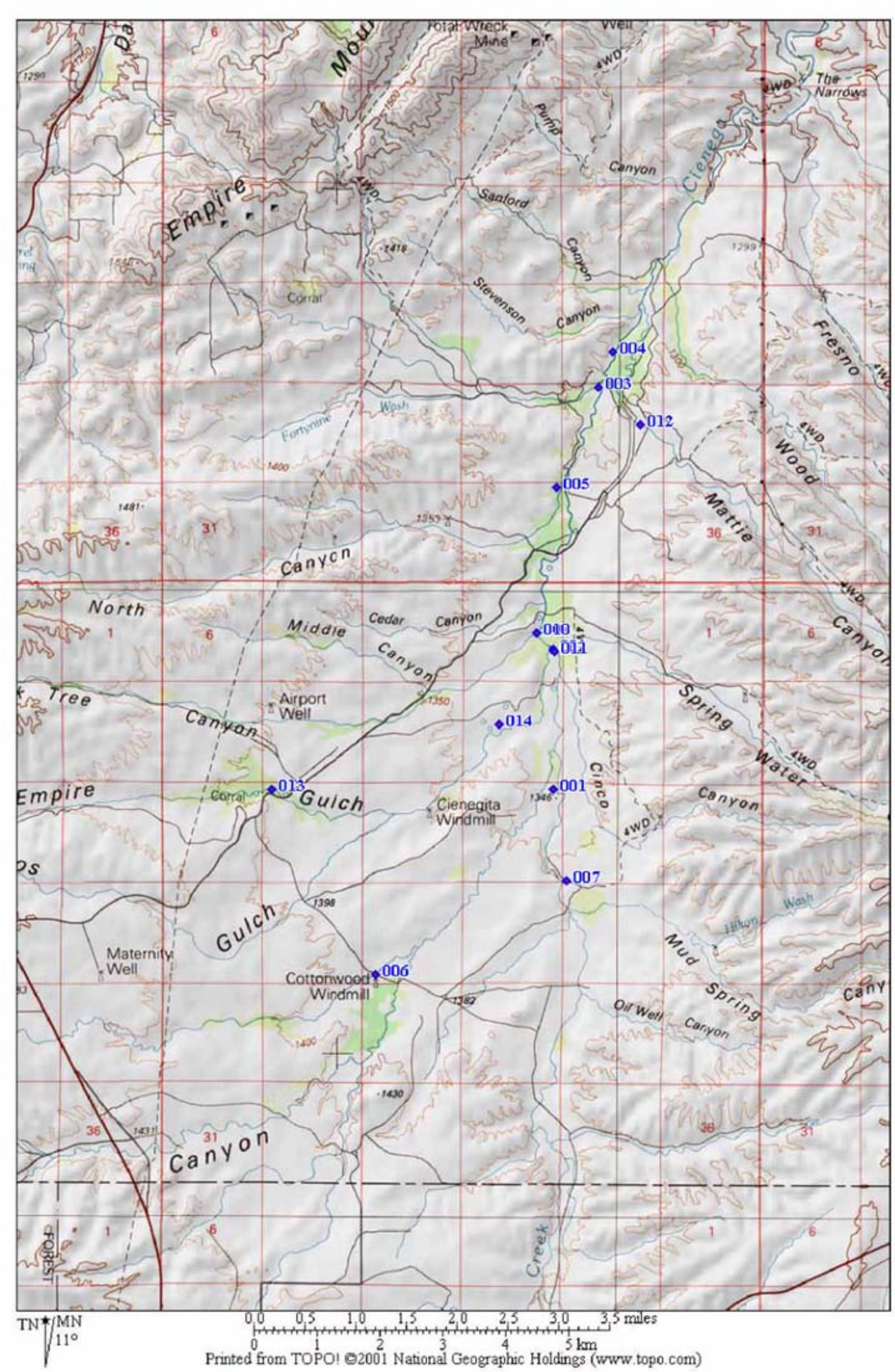
Map 3. Distribution of the Giant Spotted Whiptail (*Cnemidophorus burti stictogrammus*) observed at Las Cienegas during 2002-3.



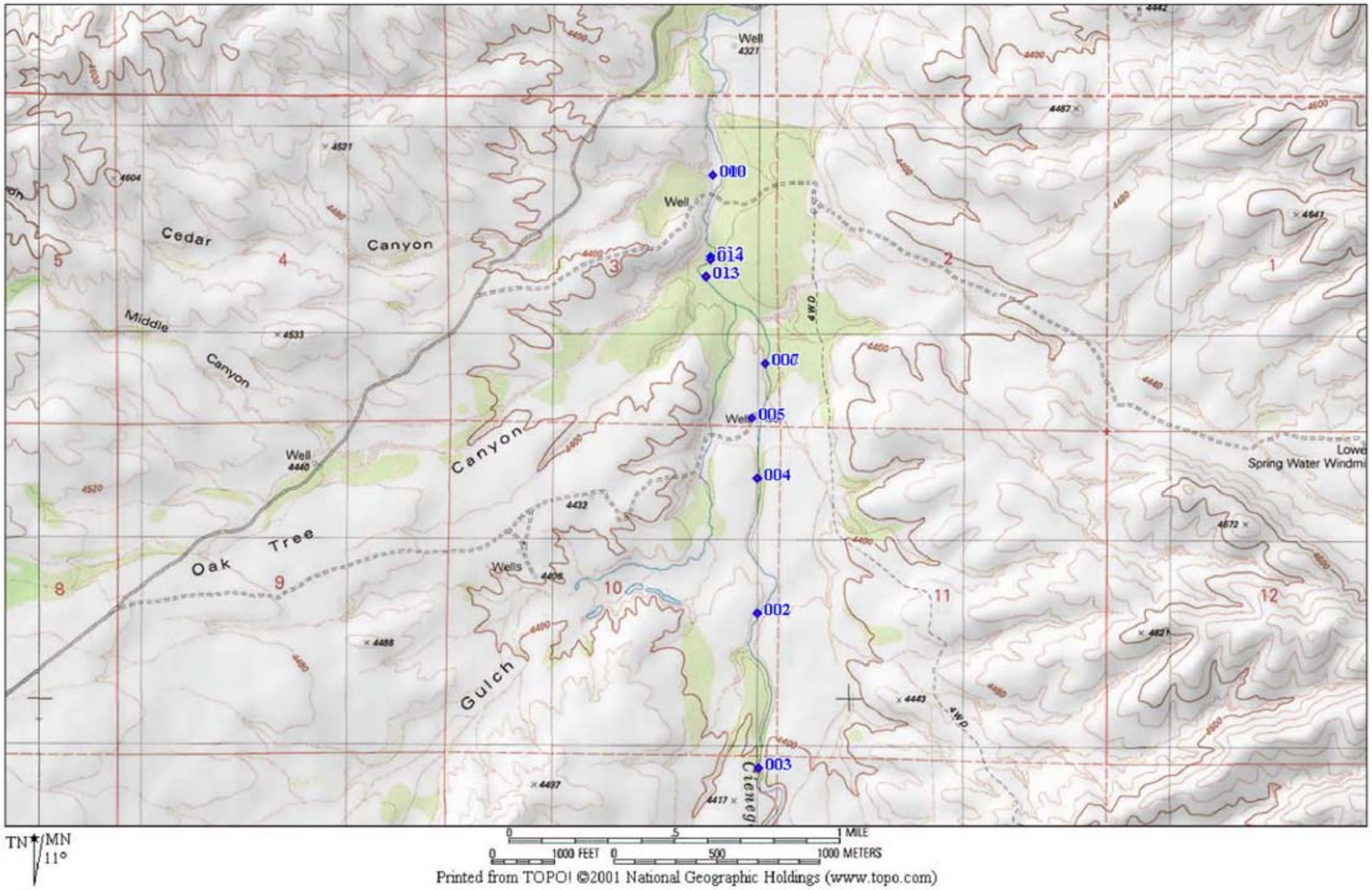
Map 4. Distribution of the Madrean Alligator Lizard (*Elgaria kingii*) observed at Las Cienegas during 1996-2003.



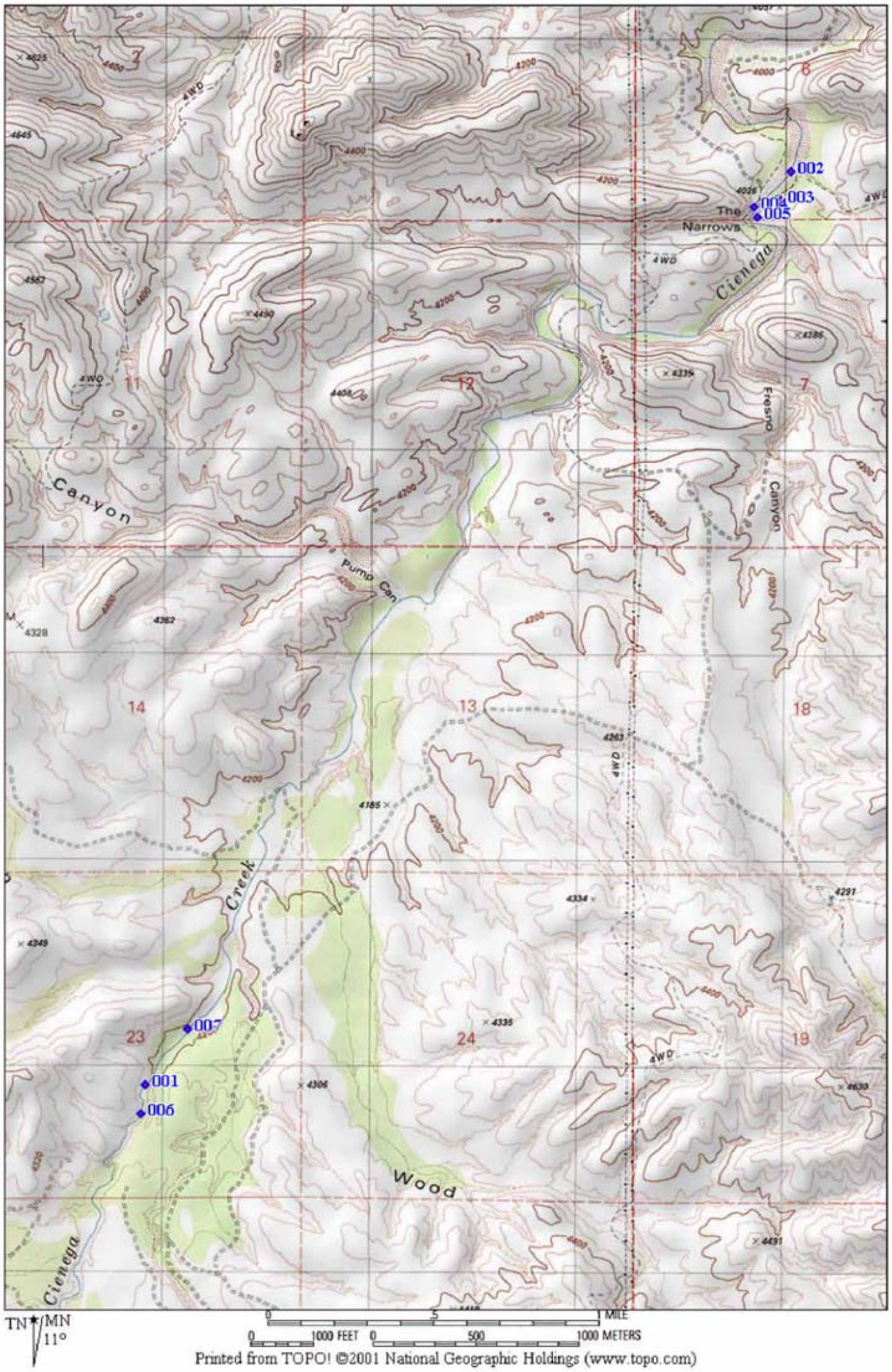
Map 5. Distribution of the Clark's Spiny Lizard (*Sceloporus clarkii*) observed at Las Cienegas during 2002-3.



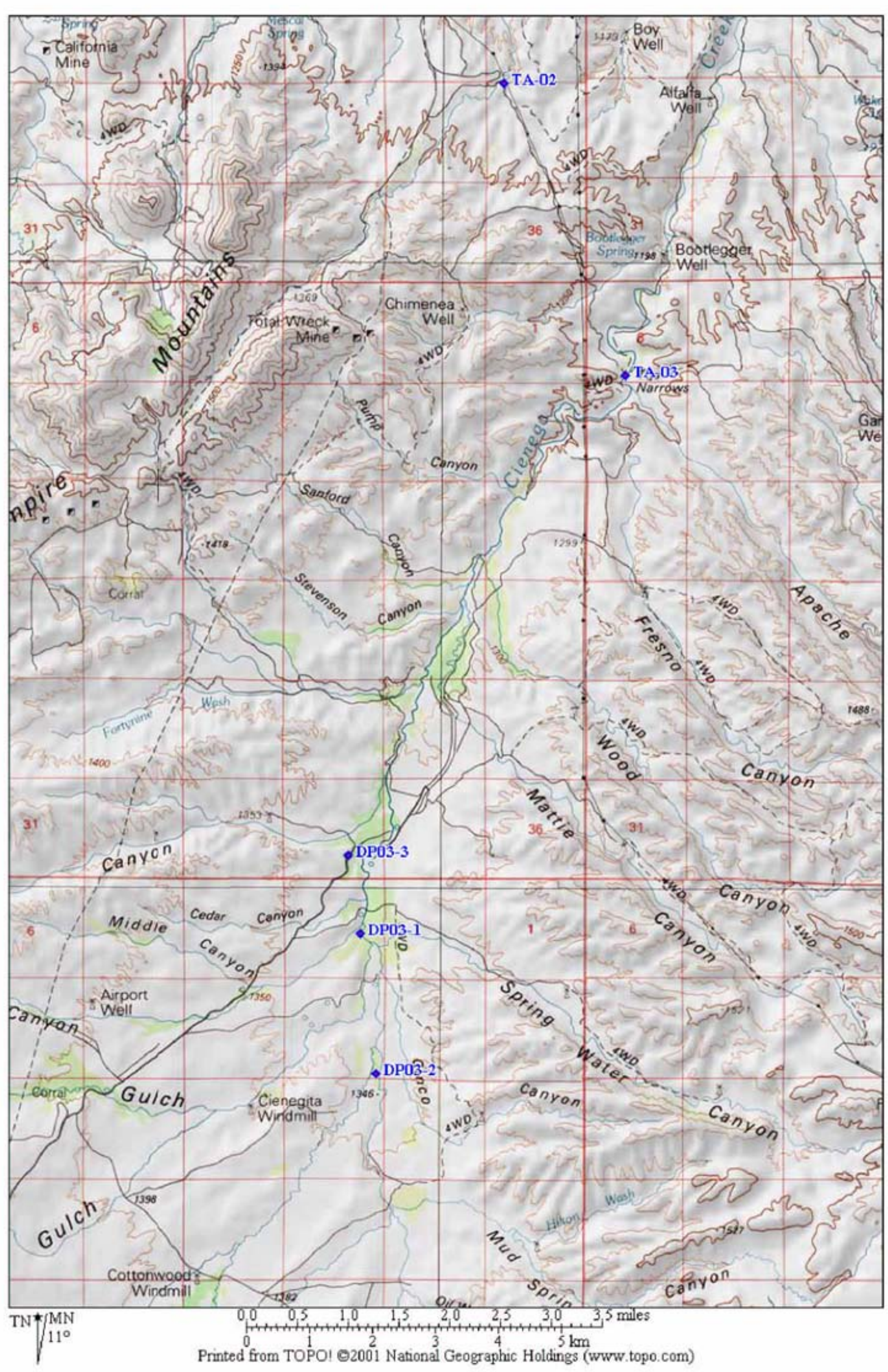
Map 6. Distribution of the Southern Prairie Lizard (*Sceloporus undulatus consobrinus*) observed at Las Cienegas during 1996-2003.



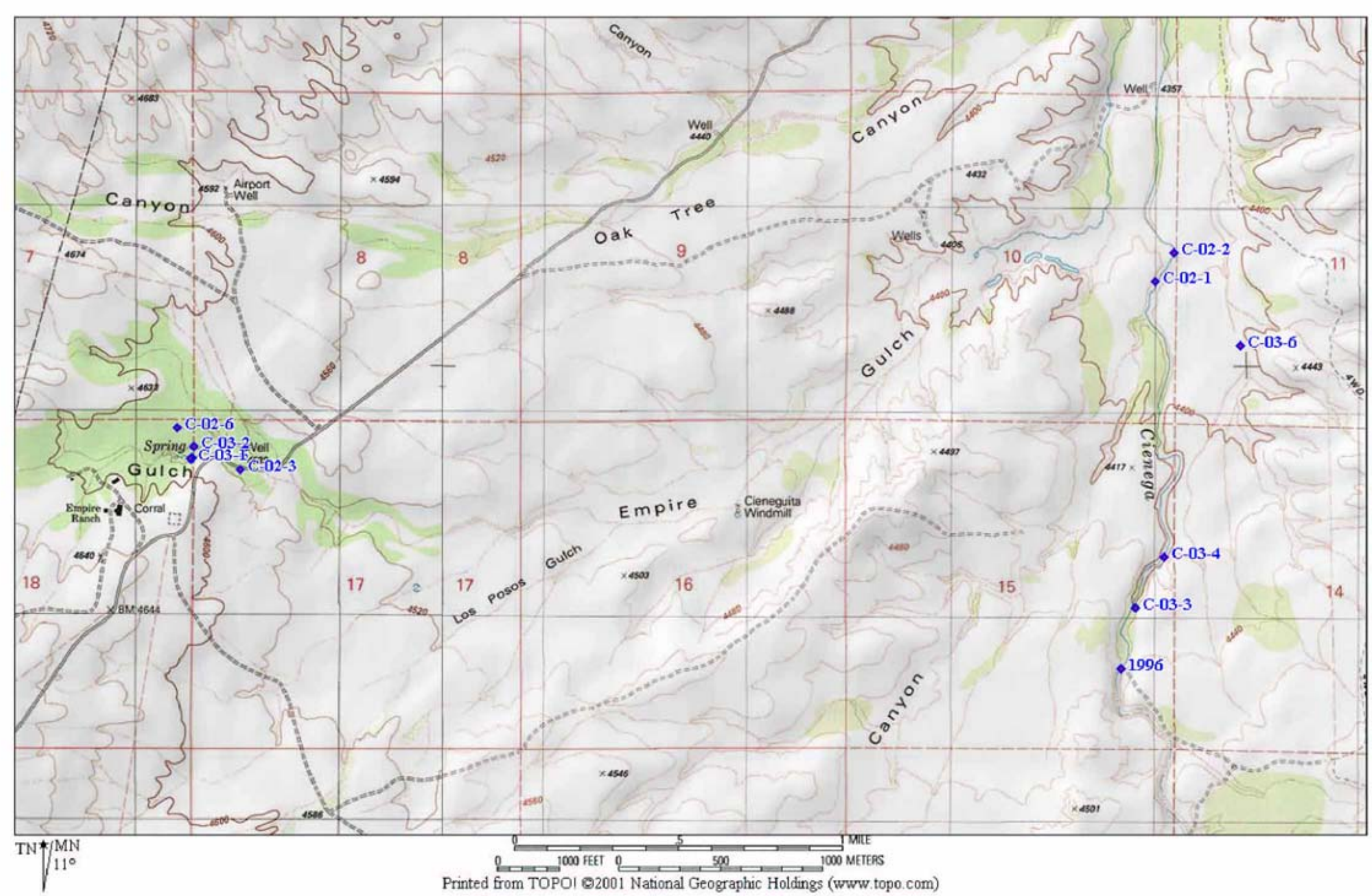
Map 7. Distribution of the Slevin's Bunchgrass Lizard (*Sceloporus slevini*) observed at Las Cienegas during 2002-3.



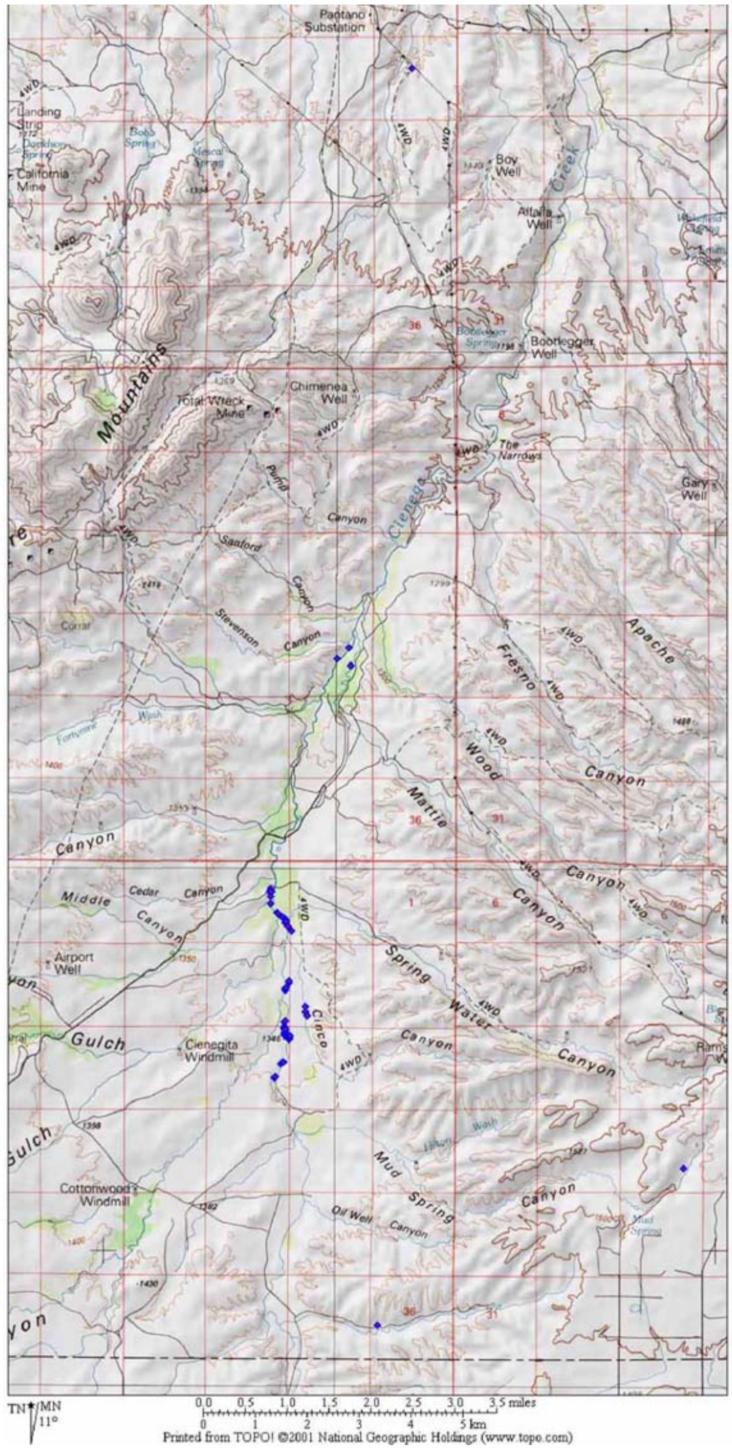
Map 8. Distribution of the Sonoran Whipsnake (*Masticophis bilineatus*) observed at Las Cienegas during 1985-2003.



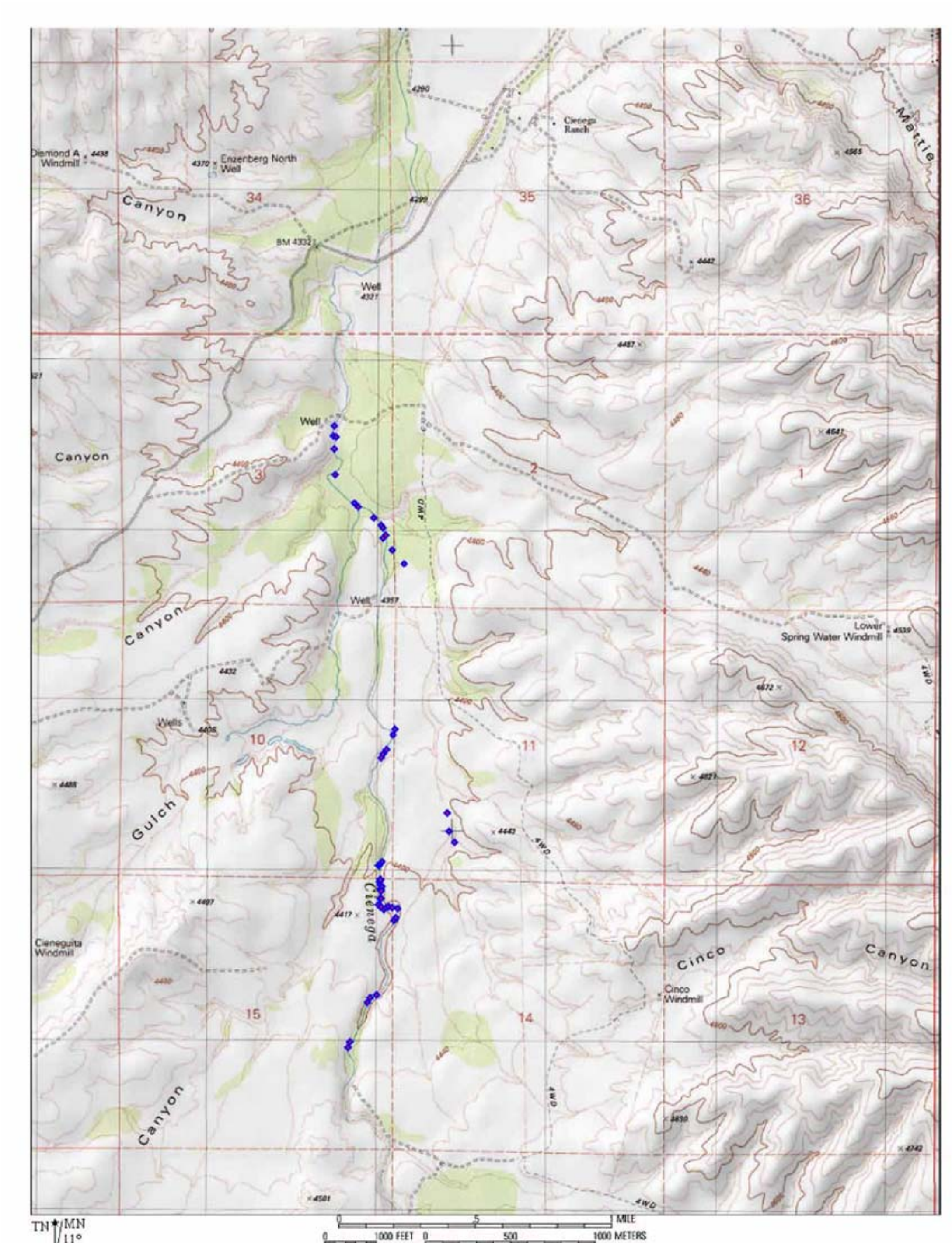
Map 9. Distribution of the Ring-necked Snake (DP – *Diadophis punctatus*) and Southwestern Black-headed Snake (TA – *Tantilla hobartsmithi*) observed at Las Cienegas during 2002-3.



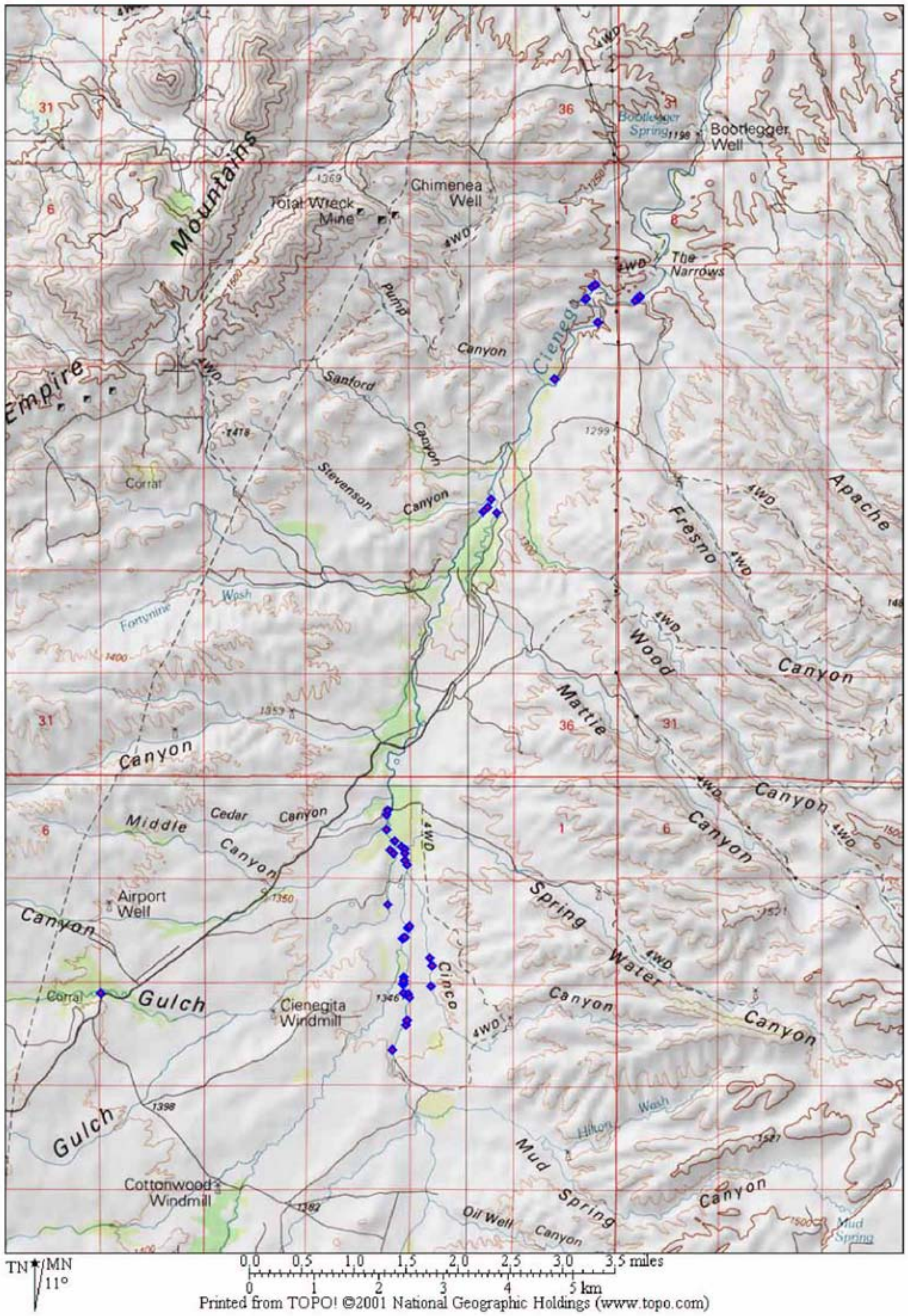
Map 10. Distribution of the Chiricahua Leopard Frog (*Rana chiricahuensis*) observed at Las Cienegas during 1996-2003. Years are indicated as 1996, '02, and '03.



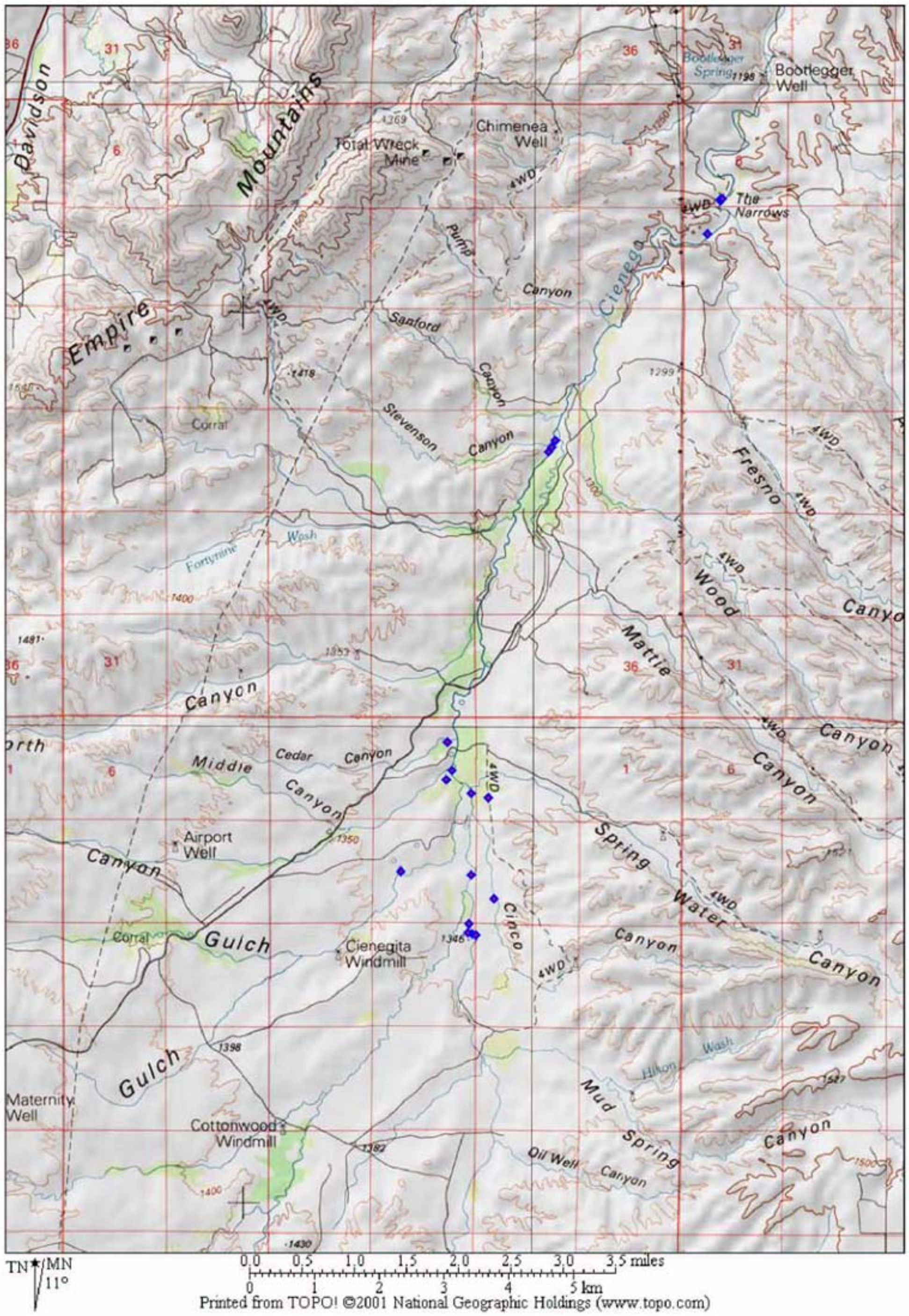
Map 11. Distribution of the American Bullfrog (*Rana catesbeiana*) observed in the Las Cienegas region during 2002-3.



Map 12. Distribution of the American Bullfrog (*Rana catesbeiana*) population observed in the upper area of Las Cienegas during 2002-3.



Map 13. Distribution of the Sonoran Mud Turtle (*Kinosternon sonoriense*) observed at Las Cienegas during 2002-3.



Map 14. Distribution of the Mexican Garter Snake (*Thamnophis eques*) observed at Las Cienegas during 2002-3.