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Amphibian Declines and Environmental Change in the Eastern Mojave Desert

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Abstract

Eight amphibian taxa historically inhabited sparsely distributed wetlands in the Mojave Desert of western North America, habitats that have been dramatically altered or eliminated as a result of human activities. Changes in the distributions of these and two introduced amphibians, and associated environmental changes, are evaluated herein for an approximately 20,000 km^2 area in the eastern Mojave Desert. Striking changes are the extinction of the Vegas Valley leopard frog, reduction in range of the relict leopard frog to only five populations, elimination of the Arizona toad and Great Plains toad from the study area, range expansion of the Woodhouse's toad, and introduction of the American bullfrog. These changes took place in concert with conspicuous loss or alteration of lowland wetlands resulting primarily from ground water pumping and development in the Las Vegas and Pahrump Valleys; formation of reservoirs and water diversions along the Colorado, Virgin, and Muddy rivers; and the introduction of exotic predators or competitors of native amphibians, such as game fishes, bullfrogs, and crayfish. In contrast to the profound impacts in the lowlands, native habitat persists at numerous upland springs, and the two species characteristic of these wetlands, red-spotted toad and Pacific chorus frog, remain common. Nevertheless, many upland springs have suffered degradation from water diversion or sequestration, trampling by wild horses and burros, and recreational and urban development, and evidence indicates that such degradation adversely affects these two species. Protection and restoration is possible for many upland springs and wetlands of the Muddy River.

Introduction

A number of amphibian species inhabit the Mojave Desert of western North America, all of which are restricted year round to the close vicinity of ephemeral or permanent wetlands. Prior to development in the 1900s, wetland habitats consisted primarily of rivers with scattered wetlands in the flood plains, spring-fed wetlands in some of the major valleys, and small, often ephemeral springs or catchments in the rocky uplands. Unfortunately, nearly all of the original wetlands in the region have been modified by human activities, often to the extent of eliminating the native riparian and aquatic habitats entirely. Such activities include impoundments, water diversion, ground water pumping, grazing/trampling, and urban and agricultural development. In addition, numerous species have been introduced comprising predators, competitors, or agents of habitat change, including many fishes, American bullfrog (*Rana catesbeiana*), red swamp crayfish (*Procambarus clarkii*), and salt cedar (*Tamarix* spp.; Jennings and Hayes 1994; Carey *et al*. 2003). Concomitant with these changes, the native aquatic fauna of the study area (described below) has also changed. For example, extinctions include three species of fish (*Rhinichthys deaconi*, *Empethrichys latos pahrump*, *E. l. concavus*), one species of springsnail (*Pyrgulopsis coloradensis*), and one taxon of frog (*Rana fisheri*, taxonomy discussed below; Minckley and Deacon 1968; Miller

1984; Miller *et al*. 1989; Jennings and Hayes 1994; Hershler 1998; D.W. Sada unpublished).

Ten amphibians have, or once had, nominal geographic ranges that include a large fraction of the eastern Mojave Desert region (Stebbins 2003), a portion of the Mojave Desert that historically had the greatest extent of wetland habitat and richest amphibian fauna within this desert. These species are the Vegas Valley leopard frog (*Rana fisheri*; taxonomy discussed below), relict leopard frog (*R. onca*), American bullfrog, red-spotted toad (*B. punctatus*), Arizona toad (*B. microscaphus*), Woodhouse's toad (*B. woodhousii*), Great Plains toad (*Bufo cognatus*), Pacific chorus frog (*Pseudacris regilla*), Great Basin spadefoot (*Spea intermontana*), and tiger salamander (*Ambystoma tigrinum)*. This article summarizes the changes over the past century in the population status and distribution of these amphibians in a portion of the eastern Mojave Desert, and identifies anthropogenic environmental changes associated with these changes. These findings are based primarily on amphibian surveys, habitat sampling, and compilation of historical amphibian records for the study area conducted in the late 1990s (Bradford *et al*. 2003; Bradford *et al*. 2004; Bradford *et al.* in press).

Study Area

The geographic area addressed herein is approximately 20,000 km^2 in southern Nevada and adjacent portions of California and Arizona (Figure 1). It is located in the eastern Mojave Desert (MacMahon 1985) and includes a number of distinct mountain ranges and intervening valleys, ranging in elevation from 210 m along the Colorado River to 3630 m in the Spring Mountains. The area drains primarily to the Colorado River system, but also includes or drains to several enclosed basins. It excludes the Ash Meadows area of southern Nye Co., Nevada.

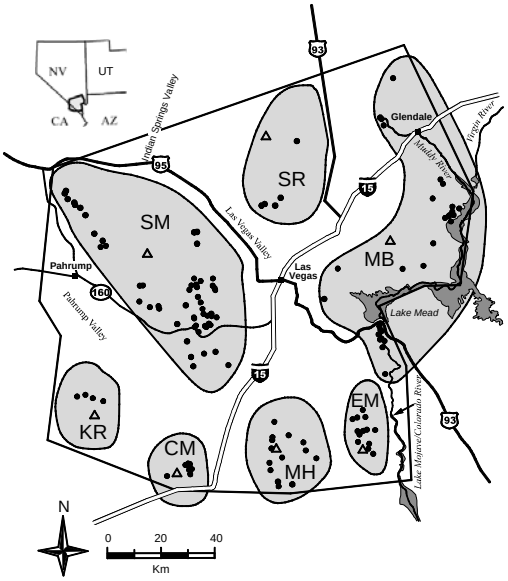

Figure 1. Figure is modified from Bradford *et al.* (in press). Study area (outline) and upland springs surveyed for amphibians (closed circles; n=128) in the eastern Mojave Desert. Shaded areas represent mountain range groups: CM = Clark Mountain Range, EM = Eldorado Mountains, KR = Kingston Range, MB = Muddy and Black mountains, MH = McCullough and Highland ranges, SM = Spring Mountains, SR = Sheep Range. High point in each mountain range group is indicated by a triangle.

Wetland systems formerly inhabited by amphibians in the study area can be described as three types: river flood plains, specifically the Colorado, Virgin, and Muddy rivers; spring-fed wetlands in the major valleys, specifically the Las Vegas, Pahrump, and Indian Springs valleys; and upland springs, generally in rocky terrain and scattered throughout the study area. Wetlands of all three types have been substantially impacted by anthropogenic activities during the past century. The formation of Lake Mead in 1935 and Lake Mojave in 1951 resulted in the inundation of the entire length of the Colorado and Virgin rivers within the study area. The springs that produce the Muddy River persist, but the river and its flood plain have been modified by agricultural development and water diversion (Eakin 1964). Large spring systems in the Las Vegas and Pahrump

valleys have been destroyed by ground water pumping, with the exception of Corn Creek Springs in upper Las Vegas Valley, a site that nonetheless has been greatly modified (Jones and Cahlan 1975; Soltz and Naiman 1978). Wetlands remain in these valleys, however, as a result of urban or agricultural runoff, perched water tables, wastewater flow, and the creation of decorative ponds. Among the upland springs, most continue to produce surface water, although some have been destroyed and many have been greatly modified. Such changes have resulted from the development of water for livestock, domestic use, mining, wild horses and burros, and terrestrial wildlife, along with surface disturbance by wild horses, burros, and recreational and urban development.

Changes in Amphibian Distributions

Unless otherwise stated, the species accounts below have been derived from Bradford *et al*. (2003) and Bradford *et al.* (in press).

Vegas Valley leopard frog (*Rana fisheri*). The taxonomy of the leopard frogs of Las Vegas Valley is unclear, with the taxon treated in the past as *Rana fisheri*, *R. onca*, or a subspecies of *R. onca* (Jennings 1988; Jaeger *et al*. 2001; Stebbins 2003). For convenience, it is treated herein by its original name *Rana fisheri* (Stejneger 1893). The frog formerly occurred in the permanent springs and wetlands in the Las Vegas Valley, and was last seen in the 1940s (Stebbins 1951; Jennings and Hayes 1994).

Relict leopard frog (*Rana onca*). The known historic range and habitat for this frog was permanent wetlands in the vicinity of the Colorado and Virgin rivers and their tributaries from approximately Black Canyon, Arizona and Nevada, below Lake Mead to approximately Hurricane and Gunlock, Washington County, Utah (Bradford *et al*. 2004). It currently is known from only five sites, three in Black Canyon, Nevada, and two near the Overton Arm of Lake Mead, Nevada, although new populations are being established through active management.

American bullfrog (*Rana catesbeiana*). Bullfrogs were introduced to the area around 1920 (Jennings and Hayes 1994) and are now widespread among the permanent wetlands in Las Vegas Valley, Indian Springs Valley, and the Muddy River and Virgin River valleys. It also occurs at a few upland springs. Its status in the artificial wetlands in Pahrump Valley has not been documented, but it is common in the Ash Meadows area outside the study area to the northwest of Pahrump Valley.

Red-spotted toad (*Bufo punctatus*). This species is common among upland springs in all mountain range groups in the study area except for the Sheep Range (Figure 1), occurring at nearly three-quarters of the sites surveyed. The species appears to have not changed in distribution among upland springs, having been found at all 16 historical spring localities surveyed. The species occurs typically at rocky sites with relatively open bank cover, and mostly ephemeral water. Red-spotted toads were also known from one lowland site, Willow Beach along the Colorado River, prior to the formation of Lake Mojave.

Arizona toad (*Bufo microscaphus*). The Arizona toad formerly occurred in the study area only in Las Vegas Valley, where it was reported as “common” at the spring-fed wetlands in the Valley (Slevin 1928). It was the only toad species reported from the Valley in the early 1900s. Sometime between 1925 and 1976, Arizona toad populations disappeared from the Las Vegas Valley, and Woodhouse’s toad appeared and became widespread.

Woodhouse’s toad (*Bufo woodhousii*). In the 1930s to 1950s, Woodhouse’s toad occurred along the major rivers in the study area (Colorado, Virgin, Muddy), and in lower Meadow Valley Wash. It persists and is common in these areas today, but has expanded into wetlands of Las Vegas Valley and upland springs in the southeastern portion of the Spring Mountains. This expansion may have occurred by dispersal along the Las Vegas Wash after a permanent wastewater stream was formed, or by direct introduction by humans, or by both.

Morphological analysis of historical and contemporary specimens from the study area indicates that the populations represent hybrids with the Arizona toad, but with traits predominantly of Woodhouse's toad. Such hybrid populations have persisted for at least the past 50 years within and outside the study area along the Virgin River between approximately the former confluence of the Virgin and Colorado rivers, Nevada, and the vicinity of St. George, Utah (Blair 1955, Sullivan 1993, 1995).

Great Plains toad (*Bufo cognatus*). This species was collected within the study area at three localities in the vicinity of the Colorado and Virgin rivers between 1936 and 1950. It appears to no longer occur within the study area.

Pacific chorus frog (*Pseudacris regilla*). Historically, this species was known from Las Vegas Valley, Pahrump Valley, Muddy River Valley, and upland springs in the Spring Mountains. The species has persisted in recent years in at least the Las Vegas and Muddy River valleys, although multiple visits have failed to reveal the species at Corn Creek Springs, an isolated historical locality in Las Vegas Valley. The species is common among springs on the eastern side of the Spring Mountains, with one occurrence on the western side. Among upland springs, it was not encountered at three of the six historical sites surveyed, all of which have been substantially modified. Like the red-spotted toad, sites with this species are generally rocky with relatively open bank cover, but typically have more extensive riparian vegetation than many of the sites occupied by the toad.

Great Basin spadefoot (*Spea intermontana*). This species has been reported from Valley of Fire (La Rivers 1942), and a specimen was collected from lower Meadow Valley Wash. Surveys in recent years have failed to detect this species. The study area is on the fringe of the species' distributional range (Stebbins 2003), and perhaps it no longer occurs within the area.

Tiger salamander (*Ambystoma tigrinum*). Larvae of this species were brought to the study area as fish bait (Stebbins 2003; J.E. Deacon, University of Nevada, Las Vegas, pers. comm.). Adult specimens have been collected at several localities in Las Vegas Valley and the vicinity of Lake Mead, Nevada. It is unknown whether these specimens represent escapees or have been derived from established populations.

Influence of Environmental Change on Amphibians

The amphibian fauna of the study area has changed dramatically in the past century. Striking changes are the extinction of the Vegas Valley leopard frog, known only from Las Vegas Valley, reduction in range of the relict leopard frog to only five populations, elimination of the Arizona toad and Great Plains toad from the study area, range expansion of the Woodhouse's toad, and introduction of bullfrogs. Lesser changes are also evident for the two additional species that had significant historical representation in the study area, red-spotted toad and Pacific chorus frog. These changes took place in concert with conspicuous anthropogenic environmental modifications. It is convenient to discuss the apparent relationships between changes in the amphibian fauna and changes in the environment relative to three general activities and associated processes. These include ground water pumping in the Las Vegas and Pahrump valleys; impoundments and diversions along the Colorado, Virgin, and Muddy rivers; and water development and other disturbance at upland springs. In tandem with all of these activities has been the introduction of a number of exotic species to aquatic systems, which can have a pronounced effect on the amphibian fauna in the southwestern U.S. (Carey *et al*. 2003).

Groundwater pumping in Las Vegas and Pahrump valleys resulted in elimination of the native spring-fed wetlands in these valleys (Malmberg 1965; Jones and Cahlan 1975; Soltz and Naiman 1978). Concomitantly, artificial wetlands have been created by perched water tables, urban

runoff, wastewater, and decorative ponds (Malmberg 1965; Jones and Cahlan 1975), and exotic predators or competitors were introduced, such as largemouth bass (*Micropterus salmoides*), goldfish (*Carrassius auratus*), mosquitofish (*Gambusia affinus*), American bullfrog, and red-swamp crayfish (Deacon 1979, Jennings and Hayes 1994). These events are believed to have been responsible for the extinction of the Vegas Valley leopard frog (Stebbins 1951; Jennings and Hayes 1994). Also, these events in concert with the expansion or introduction of Woodhouse's toad into the Las Vegas Valley are also likely responsible for the extirpation of the Arizona toad in the Valley (Bradford *et al.* in press). Such replacement of Arizona toads by Woodhouse's toads has occurred at several localities in central Arizona, typically in association with extensive alteration to riparian habitat (Sullivan 1986, 1993, 1995). The Pacific chorus frog was also undoubtedly affected by the loss of habitat in both Las Vegas and Pahrump valleys, but at least in Las Vegas Valley it persists in artificial wetlands at scattered localities.

The formation of lakes Mead and Mojave inundated the flood plains of the Colorado and Virgin rivers throughout the study area, thereby eliminating wetland habitat known to have been used by Woodhouse's toad, Great Plains toad, red-spotted toad, and relict leopard frog. Moreover, the introduction of game fishes accompanying the formation of the reservoirs likely eliminated the possibility for amphibian breeding within the reservoirs themselves. A consequence in addition to these direct effects is the prevention of dispersal and genetic exchange between the remaining populations of relict leopard frogs near the Overton Arm of Lake Mead and those in Black Canyon (Bradford *et al*. 2004). Along the Muddy River, wetland habitat has been altered by agricultural development, water diversions, impoundments, and the introduction of several fishes, American bullfrogs, and red-swamp crayfish. These changes are likely responsible for the elimination of the relict leopard frog (Bradford *et al*. 2004), but have not eliminated Woodhouse's toad and Pacific chorus frog.

At upland springs, water development and other activities have had a lesser impact on the native amphibian fauna than activities at lowland sites (Bradford *et al.* in press). Most of the original springs still exist, although impacts have occurred at many sites from various alterations for water diversion or sequestration, trampling by wild horses and burros, and recreational and urban development. Fortunately, exotic species such as fishes, bullfrogs, and crayfish, are present at a minority (9%) of the upland springs surveyed. The distribution of the red-spotted toad, a common inhabitant of upland springs throughout the study area, appears to have changed relatively little (Bradford *et al*. 2003). Nevertheless, a significant environmental factor determining the habitat suitability for this species in the study area is wetland size, measured in various ways as extent of surface water or riparian vegetation (Bradford *et al*. 2003). This implies that water development of any sort is likely to reduce the viability of a population. Moreover, when the multivariate analysis of habitat for the species described in Bradford *et al*. (2003) was redone to include factors reflecting the magnitude of impact on a spring system from various human activities in the manner of Sada and Nachlinger (1996), degradation of a site by wild horses and burros became the 8th significant parameter in the analysis. For the second-most common species at upland springs, the Pacific chorus frog, the influence of human activities may be more pronounced. The species was not found at three of six historical localities in the study area, all three of which have undergone substantial environmental degradation (Bradford *et al.* in press). Moreover, an analysis of habitat suitability similar to that conducted for the red-spotted toad revealed a strong dependency on size of the wetland system, as was also found for the toad. Thus, even though these two species currently inhabit many sites subjected to human influence, the long-term viability of their populations are likely to be influenced by anthropogenic

activities due to usurpation of water for other uses and other forms of disturbance.

The potential for restoration of amphibian habitat in the study area is limited because the magnitude of change is profound, having resulted primarily from the formation of two huge reservoirs, extensive ground water pumping, urban and agricultural development, and the introduction of exotic species that can be very difficult to eradicate. Nevertheless, protection and restoration possibilities exist for most of the upland springs and the Muddy River. Many of the upland springs can be protected from degradation by wild horses and burros by fencing, and the free-flowing state can be restored at many sites by removal or restructuring of diversion systems. In addition, manipulation of vegetation may be warranted at several sites with permanent water for the benefit of the relict leopard frog. Control of exotic species, in particular predaceous fishes, American bullfrogs, and crayfish, is worth exploring for portions of the Muddy River system, which could allow for the re-establishment of the relict leopard frog.

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Notice

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