PETITION TO LIST THE CHIRICAHUA LEOPARD FROG *Rana chiricahuensis* AS AN ENDANGERED SPECIES

SOUTHWEST CENTER FOR BIOLOGICAL DIVERSITY
ENDANGERED SPECIES SERIES No. 39

EXECUTIVE SUMMARY

The Chiricahua Leopard Frog, one of several southwestern ranid species, declined rapidly this past quarter century due to loss of habitat and introduction of exotic species. It historically occurred on the Mogollon Plateau in Arizona and New Mexico and the Sky Islands of southeastern Arizona, southwestern New Mexico, and northern Mexico. Today, the Chiricahua Leopard Frog occupies fewer than 87 sites rangewide. Extant populations are severely isolated, placing the species in danger of extinction from demographic and environmental stochasticity and genetic inbreeding.

Livestock grazing, groundwater pumping, agricultural diversion, and dams are the major causes of habitat loss for the Chiricahua Leopard Frog, which is dependent on perennial water in stream backwaters, cienegas, slow flowing stretches of rivers, plunge pools, marshes, lakes, ponds, and springs. Because of native habitat loss, the Chiricahua Leopard Frog now uses stock ponds in many localities.

Presence of exotic species, particularly Bull Frog, is correlated with absence of the Chiricahua Leopard Frog, likely because it competes with and preys on the native frog. Exotic fish and crayfish are also problems for the same reasons.

Other causes of decline include acid rain and possibly global anthropogenic changes, such as increased UV radiation caused by depletion of the ozone layer, which is hypothesized to be causing frog declines worldwide.

The Chiricahua Leopard Frog is listed as a candidate endangered species by the U.S. Fish and Wildlife Service, who has promised to list the species for several years, but has failed to do so. As a result of this lack of action, other Federal and State Agencies have taken little action to protect the species. There currently are no conservation plans in place for the frog and it is not protected by any government regulations. Livestock grazing and other causes of habitat degradation continue unabated where the Leopard Frog currently occurs and throughout its former range.

The Chiricahua Leopard Frog is one of a multitude of sensitive, threatened and endangered species dependent on riparian habitat in the Southwest, including Gila and Apache Trout, Loach Minnow, Gila Chub, Southwestern Willow Flycatcher, and Yellow-billed Cuckoo. In total, over 100 state and federally listed species in New Mexico and Arizona are riparian dependent.

June 4, 1998

Mr. Bruce Babbitt
Secretary of the Interior
Office of the Secretary
Department of the Interior
18th and C Street, N.W.
Washington, D.C. 20240

Dear Mr. Babbitt,

The Southwest Center for Biological Diversity and David Noah Greenwald hereby formally petitions to list the Chiricahua Leopard Frog (*Rana chiricahuensis*) as endangered pursuant to the Endangered Species Act, 16 U.S.C. 1531 *et seq*. (hereafter referred to as "ESA"). This petition is filed under 5 U.S.C. 553(e) and 50 CFR 424.14 (1990), which grants interested parties the right to petition for issue of a rule from the Assistant Secretary of the Interior.

The Chiricahua Leopard frog will soon be split into two species. This petition concerns both the currently recognized species and the soon to be described species. We believe listing both forms as endangered species is in accordance with the best available scientific information. However, should the U.S. Fish and Wildlife Service decide to delay recognition of the new form as a full species until formal peer reviewed publication, it should proceed to list the currently recognized species as endangered. Since we are dealing with a taxonomic transition rather than a taxonomic debate, and since all possible taxons are threatened with extinction, it is neither wise nor legal to delay initiation of the listing process.

Petitioners also request that Critical Habitat be designed for the Chiricahua Leopard Frog concurrent with the listing, pursuant to 50 CFR 424.12, and pursuant to the Administrative Procedures Act (5 U.S.C. 553). Due to the fact that very few of either Chiricahua Leopard Frog forms (Mogollon Rim and Madrean) remain, that they have suffered precipitous declines in recent years, and the habitat destruction with associated anthropogenic effects is ongoing and impending, we appeal for emergency listing and emergency critical habitat pursuant to ESA 4 (b) 7 and 50 CFR 424.20 in order to sustain both forms *R. chiricahuensis* in the immediate future.

Petitioners understand that this petition action sets in motion a specific process placing definite response requirements on the U.S. Fish and Wildlife Service and very specific time constraints upon those responses.

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I. CLASSIFICATION AND NOMENCLATURE

As described below, the Chiricahua Leopard Frog will soon be split into two distinct species. For the purposes of this petition, "Chiricahua Leopard Frog" and "*Rana chiricahuensis*" refer to the currently recognized, unsplit species, "Madrean form" to the originally described group, and "Mogollon Rim form" to the new group. Treated as a single species, the Chiricahua Leopard Frog is threatened with extinction throughout a significant portion of its range. Likewise, the original and new species (herein called forms) are each threatened with extinction throughout significant portions of their ranges.

This petition concerns both the currently recognized species and the soon to be described species. We believe listing both forms as endangered species is in accordance with the best available scientific information. However, should the U.S. Fish and Wildlife Service decide to delay recognition of the new form as a full species until formal peer reviewed publication, it should proceed to list the currently recognized species as endangered. Since we are dealing with a taxonomic transition rather than a taxonomic debate, and since all possible taxons are threatened with extinction, it is neither wise nor legal to delay initiation of the listing process.

Scientific Name. *Rana chiricahuensis* was first described by Platz and Mecham (1979). It is a member of the *R. pipiens* complex, a group comprising 27 extant and recently extinct species of the family Ranidae. This complex, which radiated in the mid-Eocene (Corcoran and Travis 1980), is composed of two phylogenetic groups, the Alpha and Beta divisions (Hillis *et al.* 1983). Each has a North American and Mesoamerican species group. By employing biochemical analysis, namely protein electrophoresis, Hillis *et al.* (1983) determined that *R. chiricahuensis* belongs to the *R. montezumae* species group of the Alpha division. This species group extends from Arizona through the Sierra Madre Occidental to the southern Mexican Plateau.

Prior to the 1960's, most species of the *R. pipiens* complex were subsumed under the name *R. pipiens*. However, systematists began to find morphologically distinct sympatric populations with little or no hybridization, allochronic breeding seasons, unique vocalizations, and genetic differentiation, leading to the description of many new species. *R. chiricahuensis* is itself being split into two distinct species based on biochemical and morphological differences (Platz, pers. comm. 1997). The Madrean form, the originally described species (Platz and Mecham 1979), will retain its *R. chiricahuensis* Latin binomial. A description of the new form (found on Arizona's Mogollon Rim eastward into New Mexico), with its taxonomic designation, will be published by James E. Platz in 1998 (pers. comm. 1997). There will then be 8 recognized species of leopard frogs in Arizona and New Mexico. The others are *R. berlandieri*, the Rio Grande leopard frog; *R. blairi*, the plains leopard frog; *R. Onca*, the relict leopard frog; *R. pipiens*, the Northern leopard frog; *R. subaquavocalis*, the Ramsey Canyon leopard frog; and *R. yavapaiensis*, the Lowland leopard frog. This is nearly all native United States leopard frogs; the only species not in these two states are *R. fisheri*, the Vegas Valley leopard frog, and *R. utricularia*, the southern leopard frog.

Common Name. Members of the *R. pipiens* complex are known as leopard frogs. *R. chiricahuensis* is called the Chiricahua Leopard Frog (Platz and Mecham 1979). Before formal description, Platz (1976) referred to *R. chiricahuensis* as the "southern form", and Fritts *et al.* called it the "Southern Leopard Frog" in their 1984 paper. The new species is as yet unnamed (Platz, pers. comm. 1997). Sredl *et al*. (1997) referred to the two forms in Arizona as the northern "Rim form" and the "Southeastern form". However, in New Mexico, unlike in Arizona, there is not a clear division of the forms into north and south (Figure 1). The originally described species is found in both the northern and southern *R. chiricahuensis* regions (Platz, pers. comm. 1997). It is also found in Mexico. Thus, to avoid confusion, forms will be referred to here with descriptors that reflect their entire distribution: "Mogollon Rim form" and "Madrean form". If no distinction is made, then the same applies to both species.

II. SPECIES DESCRIPTION

General Nontechnical Description. The Chiricahua Leopard Frog can be distinguished from other members of the *R. pipiens* complex by several key characteristics. These include: white-tipped tubercles on the dark, rear surface of the thigh; the absence of a stripe above the mouth; upward-turned eyes; poorly defined dorsolateral folds; and brown dorsal spots that lack lighter-colored halos. It is also stouter than other leopard frogs, has a broad head and short snout (figure 2), and a unique snore-like mating call.

R. chiricahuensis tadpoles are darker than those of other leopard frogs. The tail has dark patches, which may fuse, and is short and shallow relative to others of the *R. pipiens* complex (figure 3). Tadpoles are morphologically variable in some traits as a result of aquatic habitat type (Scott and Jennings 1985).

Technical Description. The Chiricahua Leopard Frog was designated a unique species based upon genetic (reflected by protein electrophoresis), morphological, and vocal characteristics. (For holotype description see Platz and Mecham 1979). Other concise reviews include Degenhardt *et al.* 1996, Snyderman 1995, and Fritts *et al*. 1984. The dorsolateral folds in this species are poorly defined or discontinuous, and are inset medially or are indistinct. The tubercles between these folds are blunt. The tubercles on the posterior surface of the thigh are white-tipped, contrasting sharply with the dark background. A supralabial stripe is absent. The venter is dull white or yellow, occasionally with gray mottling on throat and chest. Skin on dorsal limbs is relatively smooth. Small, external vocal sacs are obvious and extend posteriorly to a level even with the middle of forelimb insertion. Vocalizations consist of a snore-like trill with a very high pulse repetition (approximately 34 pulses/sec. @ 22 C) and pulse number (28-68 per call)(Degenhardt *et al.* 1996). Adult snout-to-vent length (SVL) is usually between 57 and 95 mm (Platz and Mecham 1984). Females average 76.9 and males average 64.3 mm SVL (Fritts *et al.* 1984). Other mean measurements and ranges (mm) are: tibia-fibula length, males 31.1 (32.0-39.9), females 41.3 (31.8-45.7); head width, males 26.8 (20.6-29.0), females 28.0 (22.0-32.2); head length, males 27.2 (22.2-29.5), females 28.5 (22.7-30.8); naris to lip height, males 6.5 (4.8-7.2), females 6.8 (5.1-7.9); internarial width, 4.4 (3.6-5.0), females 4.8 (4.1-5.3); tympanum diameter, males 6.7 (5.0-7.5), females 6.8 (4.8-8.0); dorsal spot count, males 26.5

(19-34), females 30.7 (20-40). Adults can weigh up to 100 g (Sredl and Howland 1994). Males of the Madrean form have vestigial oviducts. However, males of the Mogollon Rim form do not. This latter form is further distinguished by genetic differences (illuminated by protein electrophoresis), and a larger, rounder body (Platz, pers. comm. 1997).

The Chiricahua Leopard Frog tadpole has 1 or 2 rows of labial teeth on the upper labium. The unpigmented oral papillae are small and sparse run laterally to the beak (Degenhardt *et al.* 1996). The iris is dark with lateral, dorsal, and ventral dark spots (Scott and Jennings 1985). The dark tail of the tadpole, which is 60-80% of body length, has an indistinct lateral line system. Eggs are black and white with a dramatic demarcation between animal and vegetal poles.

III. DISTRIBUTION

Southwestern ranid frogs have declined markedly over the past quarter century (Applegarth 1983; Platz and Mecham 1984; Hayes and Jennings 1986; Hale and Jarchow 1988; Clarkson and Rorabaugh 1989; Jennings and Scott 1991; Sredl 1993), as have other ranids in the west (Hayes and Jennings 1986; Jennings 1988; Miller 1989; McAllister and Leonard 1990). The Chiricahua Leopard Frog is no exception. This species has a historical distribution along the southern edge of the Colorado Plateau in Arizona and New Mexico, in southeastern Arizona and southwestern New Mexico, in Mexico's Sierra Madre Occidental, and down through Chihuahua into northern Durango (figure 3)(Platz and Mecham 1979).

Knowledge of the historical distribution is due to the work of James E. Platz and his colleagues (Platz and Platz 1973; Platz and Mecham 1979; Frost and Platz 1983; Platz and Frost 1984; Platz 1976, 1984, 1993), and by Rosen and Schwalbe (1988), Hale (1992), and Sredl and Howland (1995). Platz and Mecham (1979) found the Chiricahua Leopard Frog in 72 locations (figure 3); in the intervening years this number has increased to 362 (AZ: 202; NM: ~149; Mexico: 11). When viewed on a geographic unit scale, meaning mountain ranges, valleys, or river drainages within which metapopulations do or did exist, there are 19 in which the Chiricahua Leopard Frog is present and 17 in which it is absent.

On a large scale, distribution of *R. chiricahuensis* in the U.S. is divisible into north and south, split by the low-elevation scrub desert of the lower Gila river basin. The northern populations inhabit the Mogollon Rim and White Mountains in Arizona, and the montane parts of southwestern New Mexico, encompassing the Salt, Verde, Little Colorado, Blue, San Francisco, Gila, Mimbres, and Rio Grande river drainages. Platz and Mecham (1979) found these populations to have an elevational range of 1402 to 2438 m, and Sredl *et al.* (1997) found them to range between 1067 and 2710 m (table 1). This region contains both the Madrean and Mogollon Rim forms. The Chiricahua form is found along the Arizona's Mogollon Rim and White Mountains, and populations of both forms are present where the Rim runs southeast into New Mexico, although the nature of their distributions in this area has not been elucidated (Platz, pers. comm. 1997).
The southern populations inhabit an area between the San Luis Mountains of Arizona and the Playas Valley of New Mexico, and Mexico's eastern slope of the Sierra Madre Occidental

through Chihuahua to northern Durango, encompassing the oak woodland and semidesert grassland drainages of the Madrean Archipelago. Platz and Mecham (1979) found these populations between 1219 and 1950 m, and Sredl *et al.* (1997) found them between 1061 and 2012 m (table 1). This region strictly has populations of the Madrean form. The distribution in Mexico is not well elucidated, with only 11 sites known.

Sredl and Waters (1995) believe that populations of the Chiricahua Leopard Frog have experienced the most dramatic extinction rate of all Arizona leopard frogs. Clarkson and Rorabaugh (1989) were the first to document this species' decline. It has vanished from most large rivers (for instance, Sredl and Howland, 1995, found its complete absence from large rivers such as the Santa Cruz and San Pedro) and lakes, is rare in the Chiricahua Mountains, and has decreased to only a few breeding populations in the White Mountains and Mogollon Rim, where it was common 30 years ago. Sredl *et al.* (1997) discovered that the Chiricahua Leopard Frog was absent from 84% of the historical sites surveyed in Arizona. They located only a handful of extant Mogollon Rim form sites, each with a paucity of frogs. Although there were more extant Madrean form sites, they were still extinct in at least 46% of historical sites. It is clear that the species is disappearing in New Mexico as well, even though its population status is not as well documented. Jennings (1995) found the Chiricahua Leopard Frog at only 6 of 33 localities (18%) that had been inhabited since 1984.

IV. BIOLOGY

Aside from basic reproduction, most of the Chiricahua Leopard Frog's biology is not understood. Important unknowns include intraspecific behaviors, relationships with other organisms (although see exotics, below), genetic structure, dispersal phenomena, and factors affecting fitness, recruitment, and survival.

Behavior. This elusive, nocturnal species hides in the vegetation surrounding its aquatic habitat during the day, and at night ventures further afield or onto floating vegetative matter (Degenhardt *et al.* 1996). Its activity level increases with rising nocturnal water temperature (Jennings 1990). There is a seasonal component to abundance. Numbers increase with the metamorphosis of tadpoles in August and September, and decrease from December through March (Degenhardt *et al*. 1996). The Madrean form is known to call underwater (Degenhardt *et al*. 1996), whereas this has not been observed in the Mogollon Rim form (Platz, pers. comm. 1997).

Reproduction. More aquatic than other leopard frogs, the Chiricahua Leopard Frog dwells in backwaters or slow flowing stretches of rivers, streams, and cienegas, and stock tanks, plunge pools, marshes, lakes, ponds, and springs (Platz and Mecham 1984; Fritts *et al.* 1984; Sredl and Howland 1995). It requires permanent water for reproduction. The reproductive season is habitat-dependent. Populations above 1800 m breed from June through August; those below this elevation can breed from April through September, although they usually do before June (Frost and Platz 1983; Fritts *et al.* 1984; Stebbins 1985). This phrenologic difference is likely due to water temperature. Populations inhabiting areas with large seasonal fluctuations in nocturnal water temperature have dramatic population peaks and valleys. Those inhabiting more thermally stable areas have year-round reproductive activity, and more stable population sizes. This is the case at Alamosa Warm Springs in Socorro County, where water temperatures remain warm enough for tadpoles to grow even during the winter (it never falls below 16 C). Nearby, a stock tank with more extreme temperatures was habitat for a group of *R. chiricahuensis* that bred only in spring and late summer (Jennings 1988, 1990; Jennings and Scott 1991).

Egg masses are laid near the shore of aquatic habitat. Each egg mass comprises approximately 300 to 1485 eggs (Jennings and Scott 1991). Usually they are deposited within 5 cm of the surface on vegetation growing in water 15 to 35 cm deep. Snyderman (1995) found that vegetation associated with eggs includes species of the genera *Potamogeton, Rorippa, Echinochloa, and Leersia*.

Duration of the larval stage is also dependent upon water temperature. It is completed more rapidly in warmer water. At Alamosa Warm Springs the time between hatching and metamorphosis is 2 to 3 months, whereas at sites experiencing low winter temperatures it takes 8 to 9 (Jennings 1988). Tadpoles metamorphose at about 35 to 40 mm SVL. Reproductive maturity is reached in 2 to 3 years, although Jennings (1990) and Sredl and Howland (1994) report that it may take less time. Individuals likely live to be about 4 or 5 years old (Sredl, pers. comm. 1997).

Prey Items. The prey type of the Chiricahua Leopard Frog has not been investigated, although it is assumed that it eats invertebrates opportunistically. Painter (1985) found 1 beetle, 1 grasshopper, and 4 caterpillars in the belly of one individual.

Hybridization. *R. chiricahuensis* is capable of hybridizing with *R. pipiens* and *R. yavapaiensis* in areas of sympatry in central Arizona and southwestern New Mexico (Platz and Mecham 1979). Using electrophoretic techniques, Platz and Platz (1973) and Platz (1976) found 3 hybrids out of 143 individuals sampled at three of their study sites. (It is not clear which of the forms these were). In laboratory tests, crosses of *R. chiricahuensis* with *R. pipiens* and with *R. yavapaiensis* yielded offspring 95% and 89%, respectively, as likely to survive to metamorphosis as controls. All of these test-crossed individuals that reached adulthood had reduced gamete production (Frost and Platz 1983). Rorabaugh believes that currently, because of population declines, there are very few sites of sympatry with other leopard frogs (pers. comm. 1997).

V. HABITAT REQUIREMENTS

Habitat parameters of the Chiricahua Leopard Frog are largely unknown. It is known at what elevations they occur (discussed above) and that they require permanent water, even if it dries to wet, muddy areas in the non-breeding seasons. These water sources, as mentioned above, consist of backwaters or slowly flowing stretches of rivers, streams, and cienegas, and stock tanks, plunge pools, marshes, lakes, ponds, and springs (Platz and Mecham 1984; Fritts *et al.* 1984; Sredl and Howland 1994). Sredl *et al.* (1997) found that 50% of Arizona Mogollon Rim form sites are natural lotic systems and 50% are lentic (39% are stock tanks and 11% are natural lakes and artificial reservoirs). Fifty-three percent of Madrean form sites are natural lotic systems, 45% are stock tanks. There were only 2 instances of presence in artificial reservoirs (figure 4).

Clearly, stock tanks, because of the degradation and loss of native habitats, currently furnish habitat for Chiricahua Leopard Frogs. With the onset of ranching in AZ in the late 1800s and early 1900s, construction of artificial water catchments for livestock, generally in small upland drainages, became common. As most natural systems were still relatively intact at this time, the supplementary aquatic habitat provided by stock tanks may actually have allowed native frog populations to increase for a time. Eventually, as natural aquatic habitats were altered, degraded, or lost due to surface water diversion, ground water pumping, livestock grazing practices, introduction of non-native predators and competitors, and other causes, cattle tanks provided a portion of the limited habitat left for leopard frogs (Howland *et al.* 1997). Stock tanks, however, because of their isolation and use by livestock fail to provide suitable habitat for a viable, well-connected Leopard Frog population.

Other important habitat characteristics appear to be undercut banks, which preserve wet areas during droughts, overhanging terrestrial and abundant aquatic vegetation, and aquatic heterogeneity (Snyderman 1995). It may be the lack of the latter that enables bullfrogs to out-compete and prey upon the Chiricahua Leopard Frog to devastating levels (see below)(Platz, pers. comm. 1997).

VI. CAUSES OF DECLINE

The metapopulation situation is anemic (Platz, pers. comm. 1997).

Dispersal corridors, proximal subpopulations, and uninhabited sites are integral to aquatic ranid frog metapopulation dynamics (Sjogren 1991). Sredl and Howland (1995) found that in remote, undisturbed areas of southeastern Arizona populations of Chiricahua Leopard Frogs are clustered. Within a population cluster, most aquatic sites were uninhabited. They believe that the clusters are remnants of former populations that were once continuously distributed along larger aquatic systems, or that they were peripheral subpopulations in a metapopulation that relied on a large aquatic system as its source population. They suggest that patches of aquatic habitat that are interconnected, at least intermittently, by drainages to allow dispersal are key to Chiricahua Leopard Frog metapopulation development and maintenance.

Another factor that hints to an evolutionary history of metapopulations, as well as the necessity of metapopulations for long-term persistence, is a high rate of local extinction and recolonization. Rates of reproduction and recruitment in this species are quite variable as a result of environmental influences such as rainfall (or lack of it). Because it is strongly aquatic, the Chiricahua Leopard Frog is subject to the destructive effects of floods and, more commonly, to desiccation, particularly as larvae. Also, a sudden drop in temperature often results in disease outbreaks, particularly where recent reproductive success or habitat contraction has led to overcrowding. Thus, a natural history that involves boom and bust populations makes the Chiricahua Leopard Frog especially vulnerable today. Sredl and Howland (1995) wrote "We suspect that population declines among southwestern leopard frogs can, at least in part, be attributed to disruption of normal metapopulation dynamics." Furthermore,

Small populations of leopard frogs, subjected to various forms of human disturbance, are far more likely to suffer local extinction than larger, undisturbed populations that inhabited Arizona just several decades ago. When leopard frogs disappear from a site, whether by natural or anthropogenic design, the probability of recolonization is far lower than in former times because of interrupted dispersal corridors and the lack of large riverine populations to serve as sources of dispersing frogs (Sredl and Howland 1995).

Habitat has shrunk to tiny pockets that support only small, unstable populations of Chiricahua Leopard Frogs. These habitat islands offer no dispersal corridors due to lack of water, or else potential corridors are home to introduced predators and competitors. Ground water pumping has dried much Chiricahua Leopard Frog habitat. Big rivers are no longer habitat for large source populations due to the introduction of non-natives. Furthermore, pollution and disease have detrimentally affected populations. Thus, a variety of density-dependent and density-independent factors have contributed to the Chiricahua Leopard Frog's decline, via the disruption of functioning metapopulations. The particular combination of factors differ temporally and spatially, and are often difficult to elucidate. Sredl has found that on a small scale it is usually possible to get a good understanding of the reasons for declines, but on a large scale the reasons are more veiled (pers. comm. 1997). In fact, in some cases populations inexplicably disappear under apparently stable conditions, such as at 8 Gray Ranch sites in Hidalgo County, New Mexico (Scott 1992). However, several factors clearly play a large role. These include:

Exotics. James E. Platz (pers. comm. 1997) and Rosen *et al.* (1995) believe that the decline of the Chiricahua Leopard Frog was largely facilitated by the introduction of exotics, namely bullfrogs, game fish, and crayfish. These non-natives, which once introduced, expanded over most of the Chiricahua Leopard Frog's range, displace this species through predation and competition. In the Chiricahua region, Rosen *et al.* (1995) found that the Chiricahua Leopard Frog was nearly always absent where exotics were present, and vice versa.

Bullfrogs (*R. catesbeiana*) are opportunists, preying upon nestling birds, juvenile muskrats, cotton rats, softshell turtles, spiny lizards, fish, frogs, and snakes (Schwalbe and Rosen 1988). Many native *Rana* populations have been observed to decline concurrently with bullfrog invasions (Fritts *et al*. 1984). For instance, Sredl and Howland (1995) found that where bullfrogs (and other exotics) were present in the madrean mountain ranges, the Chiricahua Leopard Frog was almost always absent. The bullfrog is devastating because it swamps the Chiricahua Leopard Frog with eggs, laying approximately 45,000 eggs per clutch (compared to the Chiricahua Leopard Frog's 300 to 1485). When the eggs of both species hatch, the tadpoles compete for food. Then, because bullfrogs have a higher growth rate than Chiricahua Leopard Frogs, they eat them (Platz, pers. comm. 1997). Schwalbe and Rosen (1995) removed bullfrogs from sites in the San Bernardino National Wildlife Refuge 2 to 3 times a year from 1986 to 1989 and in 1992. They found that bullfrog numbers would return to 44% of pre-removal levels after three months, and would completely recover to pre-removal levels by the following May, and suggest that moderate-intensity removal programs are inadequate, at least in complex systems.

Game fish that compete with and prey upon the Chiricahua Leopard Frog include largemouth bass, smallmouth bass, sunfish, trout, channel catfish, and flathead catfish. These were introduced in the 1940's and 1950's in areas such as the Gila and San Francisco rivers, and are now present throughout the Chiricahua Leopard Frog's range. They prey upon eggs, tadpoles, and post-metamorphic frogs. Catfish are benthic foragers, feeding on the floor and among vegetation, where eggs and tadpoles are (Jennings and Scott, 1991).

Introduced crayfish, also present throughout the Chiricahua Leopard Frog's range, eat frogs, compete with tadpoles for food, and reduce aquatic habitat structure (Platz, pers. comm. 1997; Fernandez and Bagnara 1995). Tiger salamanders consume eggs and tadpoles. In Arizona's White Mountains, both *R. chiricahuensis* and *R. pipiens* declined with the appearance of crayfish and tiger salamanders (Snyderman 1995). They are still absent at most sites (Schwalbe, in Snyderman 1995; Fernandez and Bagnara 1995).

Habitat Alteration.
While extinction and recolonization may have been a normal occurrence in leopard frog populations historically, it is likely that extinction rates are now higher and recolonization rates lower because of habitat degradation (Sreld *et al.* 1995).

Water Use. Damming, draining, and diverting water has fragmented formerly contiguous habitat patches (Sreld *et al.* 1995). Diversions and pumping have led to desiccation of many watercourses, including the Santa Cruz, Gila, and Salt rivers. Channelization destroys streambanks and riparian vegetation, and prevents overbank flooding and pool creation. Dams prevent flooding patterns necessary for functioning riparian systems, including regeneration, and serve as vectors for exotic species introduction.

Cattle Grazing. The onset of severe overgrazing corresponds to the beginning of widespread loss of riparian vegetation, severe erosion, and arroyo cutting- all contributing to severe degradation of leopard frog habitats (Hendrickson and Minckley 1984). Trampling and feeding cattle contribute to this process with at least two major effects:

1.) Soil compaction and large-scale loss of upland vegetation results in reductions in upland soil permeability, increased runoff, higher intensity flood events, stream downcutting and reduced dry-season flows (Arndt 1966, Branson and Owen 1970, Branson et al. 1972, Cooperrider and Hendricks 1937, Davis 1977, Gifford and Hawkins 1978, Haynes and Neal 1943, Lusby 1970, Ohmart and Anderson 1982, Smiens 1975).

2.) Widespread loss of riparian vegetation, leads to bank and soil erosion, loss of perennial flow and a widened, braided and shallower channel (Armour 1977, Behnke 1979, Behnke and

Raleigh 1979, Boldt et al. 1978, Claire and Storch 1977, Gardner 1950, Glinski 1977, Kaufman et al. 1983).

Cattle grazing continues in drainages where the last Chiricahua leopard frog populations are found, and resulting destructive processes continue to create deeply incised stream beds, increasing frequency of catastrophic flood events, and the widespread destruction of leopard frog habitat. Lack of large, falling cottonwoods, sycamores, and willows removes a prime causal factor of riverine pools; and, stock tanks serve as exotic species vectors. Finally, livestock may act as vectors for pathogens and parasites, and may contribute to anoxic aquatic conditions (Snyderman 1995).

Environmental Stochasticity. High winter rainfall can cause nearly complete mortality, such as occurred at Tule Creek, southeastern Arizona, in 1993 (Sredl and Howland 1995). Drought can decimate populations. The southeastern Arizona populations are in particular danger of complete extirpation because, except for 2, all inhabit ponds, which have a significant risk of drying (figure 7; Rosen *et al.* 1995)(additionally, see acid rain below).

Oxygen depletion may also play a large role in population declines in some areas. Sredl and Howland (1995) found that hydrogen sulfide in the water of one of their study ponds was high enough to kill aquatic wildlife, including *R. chiricahuensis*. They hypothesized that a high detritus load, in concert with a decreasing water level, high water temperature, and low concentrations of dissolved oxygen created an anoxic environment perfect for an explosion of sulfer-producing bacteria. Snyderman (1995) also found anoxic conditions at several study stock tanks. He attributed this to reduced primary productivity during the winter; low levels of runoff due to scant rainfall; nutrient-laden runoff due to cattle use, which allowed anaerobes to flourish; and drought-caused mortality of flora and fauna, which increased the detritus load. He pointed out that stock tanks are not part of the evolutionary past of the Chiricahua Leopard Frog, and that the anoxia-prone water therein may exceed the conditions to which the species is adapted.

Due to the small size of most populations, demographic and genetic stochasticity likely play a role in the Chiricahua Leopard Frog's perilous status as well.

Disease. Some populations of Chiricahua Leopard Frogs have been decimated by postmetamorphic death syndrome (PDS). For instance, at Big Springs, a large site in the Chiricahua Mountains, Arizona, there was 50 to 80% mortality during the winter of 1993 due to PDS (Sredl and Howland 1995).   PDS is characterized by the death of all or most postmetamorphic individuals in a short timeperiod (Froglog 1993, no. 7). The causes of this syndrome are unknown, although frogs end up perishing from pathogens such as *Aeromonas* (Red-leg disease). There tends to be synchronous die-offs at local sites, but not regions. Furthermore, there appears to be a ripple effect, in that frogs disappear from one site, followed by neighboring sites, in an expanding perimeter. This occurred in the Sierra Nevada, California, where ranid extinctions proceeded sequentially through watersheds. It also occurred in Grant County, New Mexico, where there was a complete die-off of Chiricahua Leopard Frogs in a three year period (Froglog 1993, no. 7). Another characteristic of PDS is that dead and moribund individuals are often found after an unusually cold period. It may be that environmental factors cause sublethal stress which suppresses the immune system; additional stress, like cold, may enables pathogens such as *Aeromonas* to invade (Carey 1993). Environmental factors proposed as potential primary stressors include invasion of exotics, habitat destruction, acid rain, pollution, pesticides, and increased UV radiation (Froglog 1993, no. 7). PDS has been implicated in die-offs in several New Mexico and Arizona sites (Snyderman 1995).

Acid Rain and Chemical Toxicity. Compared to other Amphibia species investigated by Pierce (1985), leopard frogs are relatively acid intolerant. In Jennings and Scott's (1991) study of 5 New Mexico Chiricahua Leopard Frog populations, the pH was normal and was not attributed to population declines. However, there is much evidence that acid precipitation, which depresses pH, and chemical toxicity have been major factors in amphibian extirpation.

In the Santa Rita and Atascosa mountains and adjacent regions of Mexico, huge ranid die-offs between 1974 and 1984 were likely the result of chemical toxicity from smelter-produced air pollution (Hale and Jarchow 1988). Sites had water with extremely acidic pH of about 3.9 (Hale and Jarchow 1988). At this time copper smelters were unregulated, releasing large amounts of heavy metals, which precipitated out as dry precipitate and fell out in rainfall. The rain, with abnormally low pH, also causes heavy metals in bedrock to leach into streams (Clarkson and Rorabaugh 1989). Heavy metals collect in aquatic systems, and one of these, cadmium, becomes more toxic as its ratio to zinc decreases. It is then able to bond with tissues and alter metabolic processes. Frogs go into characteristic toxic symptoms, including dilated pupils and catatonia. They are then susceptible to pathogens such as *Aeromonas* and *Pseudomonas*. In the Santa Ritas there was no other reason that frogs were dying (Hale, pers. comm. 1997). In many drainages frogs were only found in the vicinity of springs. Further downstream, where the cumulative effects of acid rain were greater, ranid frogs were completely absent. The smelter in Douglas, Arizona, which was likely the primary source of acid rain (Hale, pers. comm. 1997), was closed in the mid-1980's. However, ranid frogs remain absent in several of these sites, suggesting that the problem is still manifesting itself (Hale, pers. comm. 1997; Rosen *et al.* 1995). The 3 copper smelters currently operating in Arizona, all near Chiricahua Leopard Frog habitat, are in: San Manuel, owned by BHP, and located by the San Pedro River; Hayden, owned by American Smeltering and Refining Company, and located near the confluence of the Gila and San Pedro rivers; and, Claypool, owned by Cypress Miami Mining, and located near Globe. In New Mexico there are two copper smelters and one copper mine within the Chiricahua Leopard Frog's range: Phelps Dodge Hidalgo (Hidalgo County) near the town of Playas, Phelps Dodge Chino (Grand County) near the town of Hurley, and Phelps Dodge Tyrone Mine (Grand County). There are 2 copper smelters just over the border in Sonora, Mexico: Cananea and Nacazori. Cananea is the smelter closest to the southern Arizona populations. In the 1970's, a tailings pond at this smelter breached, pouring toxic residue into the headwaters of the San Pedro River. The spill killed aquatic species on both sides of the U.S.-Mexican border. More insidiously, the smelters may be a big contributor to acid rain, particularly since regulations may not be as strict as in the U.S. (Platz, pers. comm. 1997). Even when filters are in place, it is not known if they reduce emissions to levels that allow ranid populations downwind to persist (Hale, pers. comm. 1997). It is clear that acid rain is a widespread problem, at least in the southern areas. In the Malpai Borderlands (Cochise County, Arizona and Hildago County, New Mexico), populations of Chiricahua Leopard Frog crashed in 1997. Aquatic pH was 3.8, a result of acid rain from copper smelters (Schwalbe, pers. comm. 1997).

Agricultural herbicides and pesticides have been implicated in the decline of amphibians (Hall and Henry 1992). The degree to which they are important in the Chiricahua Leopard Frog's decline is not known. However, agricultural expansion in the Gila River, San Pedro, Sulpher Springs and other river basins has certainly increased agricultural run-off in recent decades.

Global Phenomena. Amphibians may be highly sensitive indicators of environmental quality because they absorb air and water-borne pollutants through the skin. Degradation of either aquatic or terrestrial habitat will affect them since they inhabit both. Amphibian sensitivity coupled with global population declines (Barinaga 1990; Blaustein and Wake 1990; Philips 1990) points to global environmental degradation (Jennings 1995). An increase in ultra-violet B radiation, due to thinning of the ozone layer, may be a factor in global declines. UV radiation, emitted by the sun, has higher frequency and shorter wavelength than visible light. It can permanently damage nucleic acids, kill cells, and cause mutations. Blaustein *et al.* (1994) found that there is differential sensitivity to UV radiation among anuran species. There was an 80-fold difference in the abilities of eggs from these species to repair UV radiation damage to DNA, and in hatching success. This is because some species have relatively low photolyase activity. The leopard frog in the study (*R. cascadae*) was one of these.

VII. CURRENT STATUS

> . . . the different insults share a common result: potentially disastrous mortality with possible extinction of local populations (Sredl and Howland 1995).

The Chiricahua Leopard Frog inhabits 76 sites in Arizona (Sredl *et al.* 1997)(Appendix B) and 11 in New Mexico (Jennings 1995)(Appendix C), based upon observations since 1985 (dates prior to this are considered historical by authors, except for Sredl *et al.*, 1997, for whom it is 1993). Since 1995, the Chiricahua Leopard Frog has been observed at 47 sites (Rorabaugh, pers. comm. 1997). However, because of their boom and bust population dynamics, these numbers are sure to fluctuate. The species is absent and perhaps extinct from 88 Arizona sites (Sredl *et al.* 1997) and 35 New Mexico ones. Its status at another 38 Arizona, 14 New Mexico, and all 11 Mexico locations is unknown because these areas have not been resurveyed since 1985. It appears that the Chiricahua Leopard Frog is extinct in approximately one-half of the mountain ranges and drainages in which it has been documented, and that extinction is occurring on a regional or metapopulation scale (Rorabaugh *et al*. 1995).

Arizona. The Chiricahua Leopard Frog has experienced the greatest decline of any of Arizona's leopard frogs (Sredl and Waters 1995). Sredl *et al.* (1997), of the Arizona Game and Fish Department, have recently completed the most extensive survey of Arizona's Chiricahua Leopard Frogs thus far. The AGFD assessed the status and current distribution of all of Arizona's native ranids by surveying historical and high potential areas between 1990 and 1997. They conducted 1527 surveys for the Chiricahua Leopard Frog, finding them extinct (defined by frog absence at a location for three consecutive years) in 88 and extant in 21 historical sites (38 historical sites remain unsurveyed); 55 new sites were found to contain this species (Sredl *et al.* 1997)(table 2). Only one or two individuals were found at many of the latter.

Mogollon Rim Form. Sredl *et al.* (1997) found that 79% of known Mogollon Rim form sites are in the higher elevation headwaters of the Salt, Verde, and upper Gila rivers, and 21% are in the Little Colorado River drainage. As mentioned above, 50% of the roughly 57 locations that members of this form have at some point occupied are rivers and streams, 39% are stock tanks, and 11% are natural lakes and artificial reservoirs. Of the 15 locations at which this form is extant (has been seen since 1993), 7 are in the Salt, 5 in the Verde, 2 in the upper Gila, and 1 in the Little Colorado river drainages (table 3). The U.S. Forest Service manages thirteen of these sites: 2 in Apache-Sitgreaves, 4 in Coconino, and 7 in Tonto national forests. The Arizona Game and Fish Department owns one site, and the remaining site is of unknown management status. Most of the Mogollon Rim form populations fall in Apache (32%), Gila (21%), and Coconino (16%) counties; the remainder are in Graham, Greenlee, Navajo, and Yavapai counties (table 4). Twenty-one historical sites were not surveyed: 14 on the San Carlos and White Mountain Apache reservations, 2 on private land, and 5 on Apache-Sitgreaves and Coconino National Forests.

At the time of the study, the Mogollon Rim form was present at 7% (n=4) and absent from 37% (n=21) of historical sites (an additional 21 sites, or 37%, were not surveyed). The form was found at 11 (19%) new sites (table 2). Thus, Sredl *et al.* (1997) found only a few occupied Mogollon Rim form sites (n=15), with very few individuals. The authors suggest that because most occupied sites are on USFS and USFG land, conservation of this form of *R. chiricahuensis* is hopeful. J. E. Platz is of the same opinion, stating that potential habitat is available (pers. comm. 1997).

The only other systematic survey of the Mogollon Rim populations since the species was described was by Clarkson and Rorabaugh (1989) from 1983 to 1987. They examined 18 historical sites along the Mogollon Rim and White Mountains in Arizona, and found no extant populations.

Madrean Form. Seventy-nine percent of known Madrean form sites are in the San Simon, San Pedro, and Santa Cruz river drainages, and 21% are in the Rio Concepcion and Rio Yaqui headwaters (Sredl *et al.* 1997). As mentioned above, 53% of these locations are rivers and streams, 45% are stock tanks, and 2% are artificial reservoirs. Sredl *et al.* (1997) found 61 sites at which the Madrean form is extant (has been seen since 1993): 36 are in the San Pedro, 10 in Santa Cruz, 8 in Rio Concepcion, 4 in Rio Yaqui, and 3 in San Simon river drainages (table 3). Forty-eight (79%) of these sites are on Coronado National Forest, 5 are on state lands, 1 is on a National Wildlife Refuge, and 7 are on private land (Sredl *et al.* 1997a). Most of the extant Madrean form populations fall in Cochise (49%), Santa Cruz (30%), and Graham (17%) counties; the others are in Pima County (table 4). Seventeen historical sites were not surveyed:

4 on National Wildlife Refuges, 6 in Coronado National Forest, 6 on private land, and 1 on military land.

At the time of the study, the Madrean form was present at 12% (n=17) and absent from 46% (n=67) of historical sites (an additional 17 sites, or 12%, were not surveyed). The form was found at 44 (30%) new sites (table 2). The authors suggest that the number and distribution of Madrean form *R. chiricahuensis*, together with its presence on federal land, dovetail to give it much conservation hope. J. E. Platz, on the other hand, believes that additional habitat for this form is largely unavailable (pers. comm. 1997).
Two earlier studies illuminate population function and threats to the Madrean form. Rosen *et al.* (1995) surveyed the Chiricahua Mountains, San Bernardino and San Simon Valleys, and surrounding Sulpher Springs (Cochise and Graham Counties, Arizona) for Chiricahua Leopard Frogs. They sampled 103 sites, determined from Clarkson and Rorabaugh (1989), and found very small populations in 11 stock tanks. The 300 subadults and adults inhabited sites at which exotic predators and competitors were absent.

The distribution of bullfrogs, found at 24 locations, reflects dispersal within drainages following initial introductions. Independent introductions were made at San Bernardino Ranch (1954 or before), lower West Turkey Creek (ca. 1983), San Simon Cienega (prior to 1973), and at Sunsites and near U.S. Rte. 80 and Tex Canyon Road (since 1984)(Rosen *et al.* 1995). Bullfrogs near Rodeo, New Mexico, Whitewater Draw, and in the Fan region of San Simon Creek are of unclear origins. Although illegal, possession and intentional spread of bullfrogs occurred even during their study. In areas without exotic predatory fishes, Rosen *et al.* (1995) encountered bullfrogs at very high densities: 1 adult per 2 m of shore. When in coexistence with exotic predatory fishes bullfrog density was much lower. Exotic fish were found at 42 sites, an increase since Minckley's 1973 study. They appeared to be present in all reliably permanent water sources; at most of these sites 1 or more species had a high population density.

Rosen *et al.* (1995) found that the two factors consistently correlated with the Chiricahua Leopard Frog's absence from sites were the presence of exotics and ephemeral, drought-prone habitat. The species is extremely unstable in this area because nearly all populations inhabit stock tanks (figure 5), which have a significant risk of drying. The authors believe that the primary reasons for decline are exotic predation, exotic competition, and chemical toxicity. They recommend a conservation strategy that controls exotics and maintains water depth in pond habitats.

Sredl and Howland (1995) surveyed, from 1990 to 1994, 265 potential Chiricahua Leopard Frog sites, including 87 of the 114 known historical ones in southeastern Arizona. This was part of the Arizona Game and Fish Department's study mentioned above. The authors covered a larger area than that of Rosen *et al.* (1995). They combined their results to those of Clarkson and Rorabaugh (1989) and other studies since 1985, and found recent presence of the Chiricahua Leopard Frog at 12 historical and 51 previously unknown sites (figure 6). The species appeared to be extirpated from the Santa Cruz and San Pedro rivers, areas that in the past were likely important habitat for source populations. In non-madrean areas (low elevation localities below the madrean evergreen forest and woodland, ecinal and oak-pine, plant community), the Chiricahua Leopard Frog was found at 3 of 21 historical sites. In Madrean areas (high elevations, encinal and pine-oak woodland or higher), the Chiricahua Leopard Frog was found at 9 of 32 historical sites.

Population sizes tended to fluctuate dramatically. For instance, at Tule Creek, their largest site, high rainfall in the winter of 1993 resulted in approximately 90% mortality. At the year's close, however, numbers had almost returned to pre-flood levels. During the same winter at Big Springs, another large site, an *Aeromonas* outbreak caused 50 to 80% mortality; the population had not completely recovered by 1994, likely due to the degrading effects of siltation. There have been dramatic declines at three smaller sites: Alamo Canyon, Thicket Springs, and Reed Springs. Extinctions occurred at the first two sites in 1992; by 1994 frogs reappeared at Thicket Springs, but not at Alamo Canyon. At Reed Springs the population decreased to only a few individuals. The smallest sites, stock ponds, had problems with toxic hydrogen sulfide levels.

New Mexico. Statewide surveys in New Mexico are not as comprehensive as those of the Arizona Game and Fish Department. Furthermore, the distributions of the Mogollon Rim and Madrean forms have not been worked out. It is known that those in the southwestern portion of the state are the Madrean form, and it appears that both forms exist in the west-central area (Platz, pers. comm. 1997). Therefore, the forms will not be examined separately here.

Fritts *et al.* (1984) were the first to compile site-specific locality data for the Chiricahua Leopard Frog. Eighty-nine populations were listed, comprising adults and/or tadpoles in Catron (n=29 sites), Grant (n=36), Hidalgo (n=21), Rio Arriba (n=1), Sierra (n=1), and Socorro (n=1) counties. In the past thirteen years sites have been revisited by R. Jennings, N. Scott, C. Painter, and P. Melhap, providing some information about population presence and extinction. Jennings and Scott (1991) studied six Chiricahua Leopard Frog populations (Alamosa Warm Springs, Socorro County; Beaverhead Pond, Sierra County; Chimney Rock Canyon, Cooney Tank, Gillette Tank, and Tularosa River, Catron County) from 1987 to 1990. Fairly large and stable populations were present at Alamosa Warm Springs (overgrazing and sedimentation are problems on this private land, which is also the only known habitat of the Alamosa Springs snail, *Tryonia alamosea*; negotiations to purchase the area or conservation easements have failed) and at Tularosa River springs and drainage (like Alamosa Springs, the springs are thermally stable). This appears to be a trend in New Mexico: populations are more stable at the spring sites, because of the reliable water, and experience greater declines at the variable, non-spring sites (Jennings, pers. comm. 1997). Later, Jennings (1995) expanded the study to a statewide survey; current understanding of species distribution and decline is primarily from these two studies.

From the work of the above biologists, it is clear that the Chiricahua Leopard Frog is present in the Tularosa/San Francisco, Mimbres, Alamosa/Seco/Rio Grande, Gila, Playas, and Yaqui river drainages in Catron, Grant, Hidalgo, Luna, Sierra, and Socorro counties (figures 7 and 8). It is also clear that they are declining at all localities, particularly stock tanks (Jennings 1995). Jennings (1995) surveyed 50 historical and 22 new sites. At 11 of these the Chiricahua Leopard Frog was extant. Only 6 of 50 (12%) historical sites contained the species; 33 of these sites has supported leopard frogs at some point since 1984. The occupied historical sites were at: Tularosa River, northeast of Aragon, Catron County (11 adults and many tadpoles); Tularosa River at Apache Creek town, Catron County (3 adults, 2 subadults, 3 juveniles); Alamosa Warm Springs, Socorro County (10 adults and tadpoles); Moreno Spring, Grant County (5 adults and several tadpoles); Grey Ranch at High Lonesome Well, Hidalgo County (4 adults); and, Grey Ranch at Lard Tank, Hidalgo County (45 frogs of all ages classes and tadpoles). Of the 5 new sites found, 4 were in the Gila National Forest (Dry Blue Creek, Catron County; West Fork Gila at mouth of Turkeyfeather Canyon, Grant County; Seco Creek, Sierra County; and, Metown Firebase near South Diamond Creek, Grant County), and 1 was at Upper South Palomas Creek, Grant County, 4 miles west of Winston. The author believes that wilderness areas of the Gila National Forest may retain the most cohesive metapopulations in New Mexico (figure 9).

VIII. INADEQUACY OF EXISTING REGULATORY MECHANISMS

United States Fish and Wildlife Service. The Chiricahua Leopard Frog is regarded as a Federal Candidate Species (formerly C1). Candidates are given no formal protection under the Endangered Species Act. The frog's status is being internally reviewed; J. Rorabaugh is preparing a proposed rule (pers. comm. 1997).

United States Forest Service. The Chiricahua Leopard Frog was listed as a sensitive species in 1989. No regional or forest-specific conservation plans are in place, and environmental assessments for timber sales, grazing allotments, and road construction projects rarely consider the species.

State Agencies. The Arizona Game and Fish Department considers the Chiricahua Leopard Frog a state threatened species. The New Mexico Game and Fish Department does not. The former department completed a four year study in 1997 that establishes a baseline for Chiricahua Leopard Frog distribution and abundance in Arizona. They are using this to identify areas of critical conservation need called Conservation and Management Zones. The Arizona Game and Fish Department is involved in captive breeding and release programs with the Phoenix Zoo and Grand Canyon University. They have translocated wild Chiricahua Leopard Frog metamorphs and adults in the White Mountains (Rim form) and the San Bernardino Valley (Chiricahua form). The individuals in the White Mountains subsequently disappeared, whereas those in San Bernardino Valley persisted and reproduced for over three years. The department successfully removed bullfrogs from a pond in the Gentry Creek drainage of Tonto National Forest, reduced their numbers and body size at sites on the San Bernardino National Wildlife Refuge, and is experimenting with bullfrog control methods. They have also assisted with the design of two Stewardship Agreements, which enable ranchers to renovate and manage stock tanks for the Chiricahua Leopard Frog as well as livestock (Sredl *et al.* 1997).

Bureau of Land Management. No special status or protection is given.

National Wildlife Refuges. In the San Bernardino National Wildlife Refuge there is an ongoing program of Chiricahua Leopard Frog introduction, watering, and bullfrog removal and exclusion. The species has been found at Buenos Aires National Wildlife Area as well.

Indian Nations. The Chiricahua Leopard Frog has been found at 6 locations on the San Carlos Apache and 8 locations on the White Mountain Apache reservations (Sredl *et al.* 1997). Neither reservation has a conservation plan for the Leopard Frog.

Private Land. Status of the Chiricahua Leopard Frog on much of private land is unknown due to difficulty with access. Thirty-one percent (62 of 202) of known Arizona localities that at have or at one point had Chiricahua Leopard Frogs are on private land (Sredl *et al*. 1997). Of the 42 of these locations surveyed by Sredl *et al.* (1997), the species was present at 8 and absent at 32.

One group of ranchers, called the Malpai Borderlands Group, is working to conserve this species on their properties in Cochise and Hildago Counties, Arizona and New Mexico, respectively. For the past ten years they have been aiding the Chiricahua Leopard Frog by maintaining water levels in stock tanks and eradicating bullfrogs (Schwalbe, pers. comm. 1997). One family transported 1,000 gallons of water per week to 2 populations of Chiricahua Leopard Frogs during the 1994 drought. Cecil Schwalbe, a University of Arizona researcher, has helped to establish new populations at five sites, and there are plans for more (pers. comm. 1997). In 1997 there was a population crash, however, with high mortality of both metamorphs and adults. Water pH was 3.8. He attributes this to the extremely acidic rain of copper smelters (pers. comm. 1997).

Such concern and participation by private landholders is not the case at Alamosa Warm Springs, however. Owners of this important Chiricahua Leopard Frog site, which covers 200 primary and 5,000 secondary acres, are apparently not interested in selling the property or conservation easements (Snyderman 1995).

Three Chiricahua Leopard Frogs have been seen on The Nature Conservancy's Mimbres River Preserve since 1993 (Snyderman 1995). This riverine property, through introductions and/or population management, has the potential to serve as an important source population for the neighboring spring and river systems.

IX. CRITICAL HABITAT DESIGNATION RECOMMENDED

Petitioners strongly recommend the designation of critical habitat for the Chiricahua Leopard Frog coincident with its listing. This includes the aquatic and terrestrial habitat of both *R. chiricahuensis* forms. Population declines are clearly exacerbated by anthropogenic factors. Because of this species' high rate of local extinction and recolonization, critical habitat should be designated at all current and historical sites in order to allow the reestablishment of functioning metapopulations.

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X. RECOVERY RECOMMENDATIONS

1. Conservation efforts should focus on metapopulation restoration and maintenance, entailing reintroductions into existing habitat and creation of new refugia. Identifying and restoring key source and stepping-stone habitat will be crucial to this endeavor, as will the development or maintenance of permanent water within each metapopulation. Metapopulations should be defined.
2. Genetic structure needs to be elucidated, including parameters such as heterozygosity, genetic variability, and gene flow within and between metapopulations. Understanding of the latter (dispersal distances) is particularly important for restoring functioning metapopulations. This can best be accomplished via microsatellite or mitochondrial DNA studies.
3. The above information can be used to expand current captive breeding and release programs, and to identify suitable source populations for translocation.
4. Annual surveys should occur at all current and historical *R. chiricahuensis* sites in New Mexico and Arizona at the height of activity.
5. Surveys for additional populations should be initiated in Grant and Catron counties, New Mexico (Rorabaugh, pers. comm. 1997), particularly in the Gila wilderness. Systematic surveys should also be initiated in Mexico.
6. Distribution of the two forms of *R. chiricahuensis* in New Mexico's Grant, Catron, Socorro, and Sierra counties (their 'northern' range) needs to be determined.
7. Conservation easements or property at Alamosa Warm Springs should be purchased.
8. Conservation agreements modeling those of the Malpai Group should be encouraged for private landholders
9. Livestock should be excluded from riparian areas on public land.
10. Stock tanks should be maintained as temporary leopard frog habitat, by maintaining water levels, reshaping tanks and vegetating stock tank banks, until riparian areas have been restored and can provide for viable populations.
11. Further research into logistically feasible methods for controlling exotics is needed.
12. Habitat heterogeneity of aquatic and terrestrial habitat needs to be increased. Oxygen levels can be elevated by increasing the duration, depth, and surface area of water.

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