CONSERVATION OF WETLAND HERPETOFAUNA

IN SOUTHEASTERN ARIZONA

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TABLE OF CONTENTS

EXECUTIVE SUMMARY iv

POPULATION LOSSES, DIE-OFFS, AND CHYTRID FUNGAL DISEASE IN LEOPARD FROGS AND THE BULLFROG IN THE ARID SOUTHWEST 1
Abstract 1
Introduction 1
Methods and Materials 2
I. Chiricahua Leopard Frog Population Monitoring Procedures 2
II. Lowland Leopard Frog Disease and Population Monitoring 3
III. Bullfrog Observations and Monitoring 4
IV. Survey Localities 4
V. Sources of Additional and Historical Data on Amphibian Mortality 4
Results 4
I. Historical and Geographic Perspectives on Frog Die-offs in the Southwest 4
II. 1990's Population Trends in Southwestern Ranid Frogs Affected by Chytridiomycosis 8
Chiricahua Leopard Frog 8
Lowland Leopard Frog 11
Bullfrog 14
Discussion 15
Recommendations for Management and Research 18
Acknowledgments 19
Literature Cited 19

STATUS REPORT ON THE CHIRICAHUA LEOPARD FROG (*RANA CHIRICAHUENSIS*) IN THE SAN BERNARDINO VALLEY AND DOUGLAS REGIONS, COCHISE COUNTY, ARIZONA, WITH AN ANALYSIS OF REGIONAL HABITAT CONDITIONS FOR THE SPECIES 31
Abstract 31
Introduction 32
Study Area and Species 32
Methods 34
Surveys 34
Monitoring 34
Re-establishment Program 35
Results and Discussion 37
I. Survey Results 37
II. Habitat Characteristics 38
III. Habitat Modification and Introduced Species Effects 40
IV. Experimental Re-establishments 42
Recommendations 46
Acknowledgments 47
Literature Cited 47

CONCEPTUAL DRAFT CONSERVATION PLAN FOR THE CHIRICAHUA LEOPARD FROG IN THE SAN BERNARDINO VALLEY REGION. 55
Summary. 55
Introduction. 56
I. Frog Conservation and Ranching, Background. 57
Expectation of Listing as Threatened. 57
Causes for Decline of the Chiricahua Leopard Frog. 58

II. Human Factors in Development of a Conservation Plan. 58
Harmonizing Conservation and Economics. 58
Funding for Frog Conservation Activity. 58
Rancher Input into the Plan. 59
Why Should A Rancher Participate? 59
III. Biology and Management in the Frog Conservation Plan. 60
The Metapopulation Concept. 60
Habitat Requirements for Planning. 60
Suitable Habitat and Habitat Maintenance 61
Suitable Regional Units for Conservation Plans. 62
Monitoring and Evaluating the Success of Recovery 63
Oversight of the Plan and Monitoring 64
IV. Legal Issues and Protections for Participating Parties. 64
Value of Agreements to Public and Private Parties. 64
Status of Managed Populations Under USFWS Special Rule. 65
Specific Forms of Population Status 65
Contingencies Resulting From Frog Population Events. 66
V. Preliminary Outline of Plan for San Bernardino Valley Area. 67
Conservation Planning Regions and Cooperators 67
Lower San Bernardino Valley Planning Area 68
Habitat Management Activities 68
Sources of Leopard Frog Stock for Translocations 69
Oversight Committee 69

RESURVEY OF THE MEXICAN GARTER SNAKE (*THAMNOPHIS EQUES*) IN SOUTHEASTERN ARIZONA 70
Abstract 70
Introduction 70
Methods and Materials 71
I. Localities Re-Surveyed 71
II. Survey Methods 72
Results and Discussion 73
I. Population trend at San Bernardino National Wildlife Refuge 73
II. Population trend and environmental setting, Audubon Research Ranch and vicinity 77
III. Population trend at Scotia Canyon, Huachuca Mountains 81
IV. Other sites where trapping was conducted 83
Lower San Raphael Valley 83
Arivaca Ciénega 84
Babocomari Ciénega 84
V. Other surveyed sites 85
Ciénega Creek at Empire-Ciénega Ranch 85
Lower Ciénega Creek at Ciénega Creek County Preserve 86
Lewis Springs and San Pedro River at Highway 90 86
Sites Re-visited Once 87
Summary of Site Descriptions 87
Acknowledgments 88
Recommendations 89
Literature Cited 93

APPENDIX I. TABULAR DATA ON LEOPARD FROG DISEASE IN SOUTHERN ARIZONA 95
APPENDIX II. COCHISE COUNTY LEOPARD FROG MONITORING SUMMARY 117
APPENDIX III. GARTER SNAKE SURVEY GAZETTEER FOR 1993-2001 134
APPENDIX IV. TABLES SUMMARIZING SNAKE OBSERVATIONS AT SBNWR. 159

EXECUTIVE SUMMARY

This report contains five interrelated parts discussing the conservation biology, ecology, and management of the herpetofauna of southeastern Arizona's lowland perennial wetlands, as well as the biology of this faunal element where it involves Madrean montane environments. This fauna includes the bullfrog (*Rana catesbeiana*), an introduced species that negatively affects native species; the Sonoran mud turtle (*Kinosternon sonoriense*), which is still thriving in the region; the checkered garter snake (*Thamnophis marcianus*), which has increased in abundance; the Mexican garter snake (*Thamnophis eques*), which has declined markedly and is here proposed for listing as a Threatened species in the United States; the lowland leopard frog (*Rana yavapaiensis*), which has declined; and the Chiricahua leopard frog (*Rana chiricahuensis*), which has declined markedly and is expected to be listed as a Threatened species in 2002. The plains leopard frog (*Rana blairi*) and yellow mud turtle (*Kinosternon f. flavescens*), which occur in relictual isolates, and have also declined; the spiny softshell (*Apalone spinifera*), an introduced species in rivers; the black-necked garter snake (*Thamnophis cyrtopsis*), which is primarily montane; and the tiger salamander (*Ambystoma tigrinum*), which is locally native and widely introduced, are briefly discussed, as are fishes and many amphibians generally found in less perennial waters. This report focuses on the conservation biology of two garter snakes and three frogs.

The core perennial water fauna is generally in a state of decline and transition, from one dominated by native Mexican garter snakes, leopard frogs, and small- to medium-sized fishes, to one dominated by the bullfrog, the less aquatic checkered garter snake, a variety of larger predatory non-native fishes, and crayfish. Both predation and competition from the non-natives appear to be contributing to the decline of native species. Habitat modification, principally in form of damming, ponding, and evening out of the drought-flood hydrological regime – which naturally characterizes this semi-arid region – appears to be a significant driving force in the ascendancy of non-natives over natives. The full extent of this indirect process is not yet known, and it is not certain how effective the restoration of natural regimes would be for biodiversity conservation, or how each individual species would respond.

The bullfrog appears to be the most uncontrollable non-native species, and the most harmful to the aquatic herpetofauna, in southeastern Arizona. We have reported on the great difficulty of controlling this species in complex wetlands in southern Arizona. For the leopard frogs, an additional cause of decline has been uncovered since 1997 – a possibly novel disease called chytridiomycosis, which is caused by a newly-described chytrid fungus, *Batrachochytrium dendrobatidis*. This disease has been present since at least 1974 in Arizona, and current evidence suggests its lethality may be triggered by some other, as yet unidentified, stressor, at least in the lowland leopard frog. That would actually be good news if proven, as there is no currently known management or conservation action to reverse or halt the spread of disease over the long-term. For the present, however, the disease makes the situation especially critical for the frogs, especially the Chiricahua leopard frog, which is already rare or uncommon in a highly contracted, fragmented distribution. What we can accomplish is active management to increase the number of populations and to sustain existing ones, to beat the disease using a metapopulation process, and to allow sufficient numbers of frogs to exist so that disease resistence may evolve.

We report here on a conservation plan for the Chiricahua leopard frog involving private ranches and public agencies. Despite the presence of disease and drought, this work has sustained

and increased the population of the frog in southeastern Cochise County. Ranchers in the Malpai Borderlands Group played an important role in this, establishing a precedent that could assist in defusing conflict between ranching and environmental concerns. An emerging problem in frog conservation, though a long-standing one since the ESA was passed, is unwillingness of ranchers to work with a federally listed species under current law. This may have disastrous consequences for ranching, as un-managed stock ponds are ideal for bullfrogs and are also a major source of dispersing bullfrogs that affect non-ranching areas. The conservation plan offered herein presents ways to protect ranchers without abnegation of conservation law.

A re-survey of the Mexican garter snake in southeastern Arizona, which was its stronghold in the U.S.A., revealed widespread evidence of continued decline since 1985-1988. Predation by bullfrogs remains primarily responsible, but there is some evidence that decline of leopard frogs is also involved. As such, competition from bullfrogs and non-native fishes – which decimate or eliminate leopard frogs – and the effect of chytridiomycosis on leopard frogs have exacerbated the decline of the Mexican garter snake. It is also possible that grazing by livestock and competition from the checkered garter snake may contribute to the observed decline. The Mexican garter snake was originally the pre-eminent perennial water snake in southern Arizona, but now it seems to be suffering from all of the anthropogenic factors impacting arid-land waters. Herein, it is recommended that this species be petitioned for listing as Threatened under federal law, and an extensive set of potential research and management projects for it is outlined.

Here, the abstracts for the sections of this reports are appended to provide more detail at the front of a rather lengthy document:

POPULATION LOSSES, DIE-OFFS, AND CHYTRID FUNGAL DISEASE IN LEOPARD FROGS AND THE BULLFROG IN THE ARID SOUTHWEST

Habitat loss and introduced species have been implicated in many ranid frog population declines in Arizona, New Mexico, and California. However, other declines are not well understood, and frogs are inexplicably absent or rare at some sites with apparently excellent habitat. During the past decade and a half, a series of leopard frog (*Rana pipiens* complex) mortality events has been observed in Arizona, primarily during the cool season. Losses and marked declines of Chiricahua leopard frog (*R. chiricahuensis*) populations, and repeated die-off episodes and population declines in lowland leopard frog (*R. yavapaiensis*) populations have been documented during this time. It appears that the phenomenon was not as pronounced in Arizona from the 1950's through the mid-1970's, although leopard frogs were found dead at sites where the Tarahumara frog (*R. tarahumarae*) died out in Arizona, 1974-1983.

We monitored populations and analyzed tissues of leopard frogs and bullfrogs (*R. catesbeiana*, an introduced species) in southern Arizona during 1993-2001. In the 1990's die-offs for which specimens suitable for analysis were obtained, chytridiomycosis was documented and appeared to be the proximate cause of mortality. Populations of *R. chiricahuensis* afflicted by this disease have declined sharply and in some cases have gone extinct. In *R. yavapaiensis*, populations affected by chytridiomycosis have not all declined markedly or rapidly, and their survivorship is being investigated by continued monitoring. *R. catesbeiana* has been confirmed to harbor the chytrid pathogen, but although winter die-offs of juveniles, and chytridiomycosis, have been confirmed, populations have increased or remained relatively stable.

It is possible that bullfrogs served as a vector that brought the pathogen to the Southwest, although this idea remains untested. Available evidence suggests that some, as yet unidentified, stressor is responsible for the current lethality of the chytrid fungus infection, at least in *R. yavapaiensis*.

However, regardless of whether the disease is naturally present, introduced, or newly evolved, it appears to threaten native Southwestern ranid frog species over large portions of their geographic ranges.

STATUS REPORT ON THE CHIRICAHUA LEOPARD FROG (*RANA CHIRICAHUENSIS*) IN THE SAN BERNARDINO VALLEY AND DOUGLAS REGIONS, COCHISE COUNTY, ARIZONA, WITH AN ANALYSIS OF REGIONAL HABITAT CONDITIONS FOR THE SPECIES (abstract)

We previously presented correlative evidence (Rosen and Schwalbe, 1995, 1998a, 2002 *in press*; Rosen at al., 1995) that introduced (non-native) vertebrates were a primary cause of recent declines of the Chiricahua leopard frog (*Rana chiricahuensis*). This frog species persists almost exclusively at sites lacking non-native species, which are widespread and abundant in Arizona. In southeastern Arizona, the bullfrog (*Rana catesbeiana*) appeared to be the most harmful species, although several larger predatory fishes, especially centrachids, also were identified as harmful.

Rana chiricahuensis has declined or disappeared in all original valley bottom ciénega strongholds and major mountain streams. It is now confined to small, unpredictable waters, greatly increasing its probability of extinction. It is gradually being replaced by the bullfrog in lakes and larger stock ponds. In large, deep, fully perennial waters, bullfrogs find optimal habitat conditions. In and near natural habitat types, habitat modification – normally in the form of impoundments – may facilitate the impact of bullfrogs on Chiricahua leopard frogs. Limited evidence points toward an ability of the Chiricahua leopard frog to persist despite the bullfrog in some unmodified ciénegas and streams. Nearby stock ponds that are semi-perennial may facilitate such co-existence, whereas perennial ones are likely to inhibit it. These ideas require further observations and more rigorous testing.

We surveyed the ranid frogs of the San Bernardino Valley-Douglas, Arizona region and established a conservation program there during 1993-2001. We used a series of bullfrog-free sites, or sites where we attempted to control or exclude bullfrogs, as re-establishment sites for the Chiricahua leopard frog. A number of sites had bullfrogs, which have proven difficult to control (Rosen and Schwalbe, 2002, *this report*), thus producing an experimental design allowing us more directly to evaluate the effect of the bullfrog. There was no evidence of successful establishment or persistence of *R. chiricahuensis* in 8 sites with bullfrogs. For 11 re-establishments without bullfrogs, we observed *R, chiricahuensis* persistence for a mean of 2.4 $\pm$ 0.39 SE yr, and for all 14 observed populations without bullfrogs mean persistence time was 3.5 $\pm$ 0.70 SE yr. These results add experimental support to the strong correlative evidence demonstrating the strong impact of non-native species.

In addition to presumed bullfrog predation and competition, re-establishment populations apparently failed due to disease (n=2), failure of artificial water supply (n=3), and unknown causes (n=1), and the history of one was not monitored. Five re-establishment sites remained successful through 2001 and three more were extant due to release of additional larvae in May 2000. Among natural populations, one failed in 1994 during drought, one drought-stricken population was managed successfully starting in 1994, one was lost due to disease, and one has persisted despite the appearance of disease and marked decline in frog abundance. The phalanx of factors assailing leopard frog populations is diverse, complicating recovery efforts. The tendency for populations supported by an artificial water source to succumb to temporary habitat desiccation, which occurred for a variety of reasons, should be noted. Counterbalancing this, the relative freedom that agencies gave the public to translocate eggs and tadpoles, as perceived need and availability of material arose, has resulted in the existence of at least 7 re-established populations as of this writing.

CONCEPTUAL DRAFT CONSERVATION PLAN FOR THE CHIRICAHUA LEOPARD FROG IN THE SAN BERNARDINO VALLEY REGION

Summary: This is a conceptual plan for private-public conservation of the Chiricahua leopard frog (*Rana chiricahuensis*), a species proposed for listing as threatened under the Endangered Species Act. The plan is based on cooperative ventures between private ranchers and public agency conservationists. It may serve as a model for frog

conservation in ponds elsewhere in the West.

The objective is to develop a plan that is agreed upon by U.S. Fish & Wildlife Service (USFWS), Arizona Game & Fish Department (AGFD), New Mexico Department of Game & Fish (NMDGF), USDA Forest Service, other agencies that may be involved, and participating ranchers and ranching organizations.

The plan will focus on voluntary public-private cooperation. The present document presents concepts that should be agreed upon by all participants before specific locations, commitments, plans, and schedules are set down as formal agreements.

The first specific plan to be developed involves private individuals associated with the Malpai Borderlands Group (MBG) in San Bernardino Valley and the Peloncillo Mountains, Cochise County, Arizona and Hidalgo County, New Mexico, in cooperation with University of Arizona, San Bernardino National Wildlife Refuge (SBNWR), and with USFWS Ecological Services, AGFD, and NMDGF wildlife biologists and managers.

Chiricahua leopard frog population numbers have declined markedly since the early 1980's. It has been eliminated from large areas by introduced species and habitat destruction, and appears to be affected by disease or pollution in ways that are not well understood. It is now most widespread and abundant in man-made ponds and tanks on cattle ranches, and may be unable to survive without them.

The relationship between public and private partners in this frog conservation plan is embodied in the following 5 points:

(1) participating ranchers and conservationists will agree, on a voluntary basis, on management that is compatible with both ranching and with frog conservation,

(2) within the agreement framework, normal ranch operations may continue and may be exempted from "take" provisions of the Endangered Species Act (based on a Special Rule, section 4(d) of the Endangered Species Act, or on other mechanisms),

(3) it is anticipated that funding for frog conservation activities will be available from various sources; ranchers will not be required to cover conservation expenses of the frog conservation work from their private funds,

(4) ranchers can materially contribute to the conservation work with their landscape knowledge, practical expertise, observations and monitoring, and

(5) improvements made to waters under the frog conservation plan may be designed to dovetail with needs of responsible livestock grazing operations.

The key landscape and ecological concepts in the frog conservation plan are embodied in the following 5 points (a-e):

(a) ranch water developments will be utilized as frog habitat, including stock ponds, steel and concrete tanks, and drinkers and wells,

(b) new populations will be established by translocation (moving) of excess or head-started (captive-reared) tadpoles or juvenile frogs from existing sites,

(c) within a plan, populations will be organized as a "metapopulation" in which different local sites can exchange individuals and genes, either naturally or by artificial interchange,

(d) individual populations within the metapopulation can be treated as core (primary) or peripheral (secondary) sites, and populations may be designated as "essential natural populations", "experimental managed populations", or "established managed populations",

(e) monitoring will focus on the success of the metapopulation and the environmental factors affecting it.

This document also points out some hypothetical pitfalls and abuses of frog conservation plans and how they might be avoided. It provides guidelines that both public and private participants should agree to in principle and in good faith. These should serve to protect both groups against real or perceived threats that are currently often expected in the relationship between government conservationists and private ranchers.

RESURVEY OF THE MEXICAN GARTER SNAKE (*THAMNOPHIS EQUES*) IN SOUTHEASTERN ARIZONA (abstract)

Mexican garter snake (*Thamnophis eques*) populations in southeastern Arizona were re-surveyed during 2000, with additional information collected during 1993-2001, at localities known to support the species during the early-mid 1980's. At the most intensively studied site, San Bernardino NWR, there was a major, systematic decline; at a second intensively studied site, Finley Tank at Audubon Research Ranch, there was also a major decline that was probably both systematic and a product of natural climatic variation. Systematic declines have been associated with high-density bullfrog populations, predatory centrarchid fishes, and disappearance of primary prey – native ranid frogs and native fishes. At a third study site, Scotia Canyon in the Huachuca Mountains, capture rates were highest in 1980-1982, lower in 1993, and lowest in 2000, although sample sizes were small. Among remaining sites, favorable results were obtained at 3 and unfavorable results at 13. The most encouraging result was an apparent increase at Ciénega Creek County Preserve, along with persistence at Empire-Ciénega Ranch. An extensive, it not abundant, population was documented in the lower San Raphael Valley. The third piece of good news was rediscovery of the Mexican garter snake at Arivaca Ciénega, although it remains rare there. In summary, findings are: increases suggested at 1 site (lower Ciénega Creek), possible stability at 2 (lower San Raphael Valley, Arivaca), negative trends or findings at 14 (Empire-Ciénega Creek, Babocomari, Bog Hole, O'Donnell Creek, Turkey Creek [Canelo], Post Canyon, Scotia Canyon, Lewis Springs [San Pedro River], San Pedro River near Highway 90, Barchas Ranch Pond [Huachuca Mountain bajada], Heron Spring, Sharp Spring, Elgin-Sonoita windmill well site, and Upper 13 Reservoir [San Raphael Valley]), and major, demonstrable declines at 2 sites (San Bernardino NWR, Finley Tank), with no documented extinctions. The Mexican garter snake was found to be in widespread, ongoing decline in southern Arizona.

POPULATION LOSSES, DIE-OFFS, AND CHYTRID FUNGAL DISEASE IN LEOPARD FROGS AND THE BULLFROG IN THE ARID SOUTHWEST

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Abstract

Habitat loss and introduced species have been implicated in many ranid frog population declines in Arizona, New Mexico, and California. However, other declines are not well understood, and frogs are inexplicably absent or rare at some sites with apparently excellent habitat. During the past decade and a half, a series of leopard frog (*Rana pipiens* complex) mortality events has been observed in Arizona, primarily during the cool season. Losses and marked declines of Chiricahua leopard frog (*R. chiricahuensis*) populations, and repeated die-off episodes and population declines in lowland leopard frog (*R. yavapaiensis*) populations have been documented during this time. It appears that the phenomenon was not as pronounced in Arizona from the 1950's through the mid-1970's, although leopard frogs were found dead at sites where the Tarahumara frog (*R. tarahumarae*) died out in Arizona, 1974-1983.

We monitored populations and analyzed tissues of leopard frogs and bullfrogs (*R. catesbeiana*, an introduced species) in southern Arizona during 1993-2001. In the 1990's die-offs for which specimens suitable for analysis were obtained, chytridiomycosis was documented and appeared to be the proximate cause of mortality. Populations of *R. chiricahuensis* afflicted by this disease have declined sharply and in some cases have gone extinct. In *R. yavapaiensis*, populations affected by chytridiomycosis have not all declined markedly or rapidly, and their survivorship is being investigated by continued monitoring. *R. catesbeiana* has been confirmed to harbor the chytrid pathogen, but although winter die-offs of juveniles, and chytridiomycosis, have been confirmed, populations have increased or remained relatively stable.

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Introduction

Essentially all of the native ranid frog species (genus *Rana*) of western North America are in decline (Vial and Saylor 1993, and therein; M. Jennings 1995; Sredl and Howland 1995) or have disappeared (Hale, et al. 1995; Stebbins 1985), with declines reported across the region (Arizona--Clarkson and Rorabaugh 1989; California--M. Jennings 1995; Colorado--Hammerson 1982; Corn and Fogelman 1984; Pacific Northwest--Leonard et al. 1993; Bahls 1992 and therein). Introduced, non-native predators and competitors are frequently associated with these declines over a broad area (Bahls 1992; Bradford 1989; Bradford et al. 1993; Bury and Luckenbach 1976; Clarkson and Rorabaugh 1989; Dumas 1966; Fellers and Drost 1993; Fisher and Shaffer 1996; Green 1978; Hammerson 1982; Hayes and Jennings 1986, 1988; Knapp and

Matthews 2000; Kupferberg 1997; Lawler et al., 1999; Leonard et al. 1993; McAllister et al. 1993; Moyle 1973; Rosen and Schwalbe 1995; Rosen et al. 1995; Schwalbe and Rosen 1988; Vitt and Ohmart 1978), and are also affecting other amphibians in the American West (Collins et al. 1988; Gamradt and Kats 1996; Matthews et al., 2001; Tyler et al. 1998), as well as elsewhere in the world (e.g., Brönmark and Edenhamn 1994; Meyer et al. 1998). For Arizona and Western North America, non-native fishes, bullfrogs, and crayfish appear to be the most widespread and consistent problem for native ranids.

However, amphibian declines have also been associated with increased ambient UV-B radiation (Blaustein et al. 1994), acid rain (Harte and Hoffman 1989), heavy metal toxicity (Hale et al. 1995), and disease (Berger et al. 1998), and such factors may interact with each other and with exotic species (Kiesecker and Blaustein 1997) as causes of decline. Further, several major declines have occurred without identified causes (Corn and Fogelman, 1984; Drost and Fellers, 1996; Hale et al., 1995; Sredl, 1997).

More recently, there have been reports of frog mortality, associated with the newly discovered amphibian disease chytridiomycosis, in western North America (Bradley et al., *in press*; Fellers et al., 2001; Hale, 2001) and elsewhere in the world (Berger et al., 1998; Bosch et al., 2001; Cary, 2000, Daszak et al., 1999, 2000). This disease is caused by a newly-identified (Berger et al., 1998; Mutchmann et al., 2000; Raverty and Reynolds, 2001) chytrid fungus (phylum Chytridiomycota: organisms previously known to decompose plants and attack insect chitin; Alexopoulos et al., 1996), which has been described as *Batrachochytrium dendrobatidis* (Longcore et al., 1999). The disease often strikes in winter, and the disease organism has been found to be more lethal at lower temperatures. Whether this disease is an ultimate cause of population declines seen in anurans, rather than the lethal symptom of one or more other stressors, remains a key question (Green and Sherman, 2001).

The Tarahumara frog (*Rana tarahumarae*) disappeared from its entire range in the United States during 1974-1983 (Hale et al., 1995), and its decline appears to be correlated with presence of chytrid infection (Hale, 2001; P. Fernandez and T. Jones, *manuscript*). The Chiricahua leopard frog (*R. chiricahuensis*) disappeared from most known localities in northern Arizona and New Mexico during the past two decades (Clarkson and Rorabaugh, 1989; Sredl, 1997), with remaining populations in New Mexico primarily at warm springs (R. Jennings, 1995; Scott, 1992; 1993). This paper reports on frog mortality, patterns of population decline, and disease in *R. chiricahuensis*, *R. yavapaiensis*, and *R. catesbeiana* in Arizona. Chytridiomycosis is widespread in ranid frogs in Arizona. It is associated with die-offs, and may be responsible for population declines that cannot be attributed to introduced species or natural drought.

Methods and Materials

I. Chiricahua Leopard Frog Population Monitoring Procedures.

Population trends documented here are based on field monitoring protocols for anurans similar to those summarized by Heyer et al. (1994). A variety of monitoring methods was employed as a matter of feasibility and convenience: frogs were monitored in a variety of ways depending on personnel, time of day, visibility, time available for monitoring, and weather. Results were used if they met the following standards: (1) the habitat area occupied by frogs at the population site was thoroughly examined, (2) the survey was carried out by a trained observer known to be competent in surveying for ranid frogs, and (3) the survey was conducted under appropriate conditions of season and weather. Direct visual counts, splash counts, and dipnet counts of individuals were recorded and enumerated according to life history stage (eggs, small larvae, large larvae, metamorphs and juveniles, subadults or small adults, average-sized adults,

and large adults). Tadpoles were excluded from the numerical result in situations where large numbers of small individuals were observed, and egg masses were also eliminated from the enumeration of total individuals observed. Generally, familiarity with localities permitted ranid frog species identification; however, I threw out data judged to contain uncertain species identifications.

For ponds, daytime counts were based on extended observations made visually, with binoculars if necessary, and followed if necessary by an attempt to flush frogs that could have been overlooked. In streams, counts were based on walking along stream sections and counting visible frogs and splashes made by escaping frogs. At night, a headlamp or bright hand-held flashlight was used to meticulously examine the habitat, and these results were sometimes supplemented by adding splashes made by unseen, escaping frogs. Most sites were monitored in unique ways adapted to conditions of accessibility and visibility, so comparison of numerical values among sites is useful only at a general level. I made many of the observations myself, but I also collected large numbers of them from data sheets filled out by field technicians and researchers and from interviews with refuge personnel at San Bernardino National Wildlife Refuge (SBNWR). I compiled all of the information into site-specific tables (Appendix), and for each site have utilized only data collected in comparable ways. It appears that different individuals and various methods useful at a site tended to produce remarkably consistent results.

II. Lowland Leopard Frog Disease and Population Monitoring.

The phenomenon of regular winter mortality events was observed during this study beginning in March 1995 (Appendix). I initiated histological investigations of frog carcasses found dead during field work in 1995 by conducting dissections with Dr. James Jarchow and forwarding specimens to the University of Arizona Veterinary Diagnostic Laboratory (VDL) where they were examined by Dr. Carlos Reggiardo and Dr. Gregory Bradley. Early findings were confusing, and it was suspected that redleg disease (caused by the *Aeromonas hydrophila* bacterium) or stress related to winter fasting and reproductive effort might be responsible for the first-observed mortality events in this study. When it became evident, in 1997, that there was a regular pattern of winter mortality in lowland leopard frogs and that major die-offs were occurring in study populations of the Chiricahua leopard frog, I arranged for more extensive testing of dead material at the VDL. Working with my advisement under the present project, Dennis Caldwell obtained fresh mortality material from the Cienega Creek County Preserve (lowland leopard frog) in 1997 and Steve Hale brought in material from SBNWR (Chiricahua leopard frog). Histological results obtained by Dr. Bradley for both species were consistent but appeared novel, and were forwarded by him to Dr. Don Nichols at the National Zoological Park, where the histological preparations were recognized to contain the newly-discovered amphibian chytrid. These represented the first known North American cases of mortality from chytridiomycosis (e.g., Milius, 1998; Morell, 1999). In cooperation with Dennis Caldwell, who mobilized the Tucson Herpetological Society (THS), and Mike Sredl at AGFD Nongame Branch, who had previously observed mass mortality events, the project reported on herein assisted in the development of a winter-time disease monitoring project (Southeastern Arizona Winter Amphibian Monitoring Project [SAWAMP]) that documented widespread ranid frog disease mortality in southern and central Arizona (Bradley et al., 2002 *in press*; this study).

AGFD Nongame personnel in the Ranid Frogs Program (Mike Sredl, Verma Miera, Brenda Healy, Kim Field, and others), THS volunteers organized by Dennis Caldwell and me (Dennis Caldwell, Chris Wolner, Erik Enderson, Allison Titcomb, Don Swann, Caren Goldberg, Jeff Morebeck, and others), and University of Arizona and SBNWR personnel working under the present project (Phil Rosen, Shawna Nelson, Eric Wallace, and others) systematically surveyed localities and anuran species in southeastern Arizona during the winters of 1999-2001. These

surveys consisted of individuals going to known ranid frog localities and conducting visual, daytime searches for and counts of dead, lethargic (or otherwise debilitated), and apparently healthy frogs.

Clean technique was used to minimize the spread of disease by field workers: apparel was cleaned and laundered, and footgear and nets were cleaned and treated with 5% bleach or other disinfectants. Specimens were put in clean plastic ziploc bags and brought live, on ice, or in 10% formalin to Dr. Bradley at the VDL, where they were checked for viral, bacterial, protozoan, and fungal infections, infestation by macroscopic parasites, general body condition, and gross lesions or injuries (Bradley et al., *in press*). In addition, a random sampling of apparently healthy frogs was taken for analysis. Samples for water chemistry analysis were collected in nalgene jars, stored on ice, and transported within 24 hours to Turner Laboratories in Tucson for standard drinking water analysis.

III. Bullfrog Observations and Monitoring.

Bullfrogs were investigated in a number of recently invaded localities that still support leopard frogs. They were removed when possible, and tissues were submitted to the VDL for analysis. Intensive bullfrog removal was ongoing at SBNWR ((Rosen and Schwalbe, 1995; 1996a, 1996b, 1997, 1998, 2002 *this report*), and those results are utilized here as an example of the resilience of the species despite the presence of disease and our removal efforts.

IV. Survey Localities.

Based on accessibility, the Tucson and Douglas regions were selected for intensive study. Lowland leopard frog populations were known in the Tucson region at Aliso Spring (Tumacacori Mountain), Montrose and Buehman Canyons(Santa Catalina Mountains), sites in Saguaro National Park and at Paige Creek (Rincon Mountains), Hot Springs Canyon (Galiuro Mountains), Cienega Creek, Aravaipa Creek, and lower San Pedro River, and all of these sites were surveyed in winter for evidence of frog mortality and disease (Appendix). Chiricahua leopard frog populations in the Douglas region were known at Leslie Creek (Swisshelm Mountains), Douglas public school ponds (at 4 campuses), SBNWR (2 population sites from which bullfrogs were excluded), and Magoffin Ranch (3 sites), and all of these were subjected to regular surveillance. Winter surveys for mortality in the Chiricahua leopard frog were also conducted at Halfmoon Tank (Dragoon Mountains) and Pinery Canyon (Chiricahua Mountains). Bullfrogs were collected for analysis at SBNWR, Cienega Creek, San Pedro River, and Altar Valley, and plains leopard frogs (*R. blairi*) were examined from the AEPCO power station ponds in Sulphur Springs Valley.

V. Sources of Additional and Historical Data on Amphibian Mortality.

I also collected and collated data supplied by field biologists who observed evidence of anuran mortality in Arizona. Dr. Phil Fernandez and Dr. Joseph Bagnara supplied transcripts of earlier field notes recorded by Dr. Bagnara and John Frost during extensive field studies of Southwestern leopard frogs in the 1980's, and Dr. Richard Zweifel provided extracts of his notes from the 1950's through 1990's in southern Arizona. These sources have provided additional material relevant to this study.

Results

I. Historical and Geographic Perspectives on Frog Die-offs in the Southwest

Leopard frogs were rare or absent at a number of sites had apparently excellent habitat,

judged on the basis of experience with the leopard frogs in Arizona and historic field notes and museum voucher records. Although leopard frogs in Arizona often thrive in artificial stock ponds ("tanks"), Table 1 lists only natural sites, since natural wetlands appear to offer greater habitat complexity and other features making them apparently optimal habitat for leopard frogs (e.g., Sartorius and Rosen, 2000; and see below). By focusing on naturally existing sites, Table 1 also avoids listing sites that may be unoccupied due to un-observed human management or recency of creation. The list produced in the table represents a substantial set of cases, in the semi-arid setting of Arizona, where absence or rarity of leopard frogs contradicts expectation.

The existence of un-occupied habitat at major sites suggests that leopard frog populations have suffered or may be suffering from subtle factors of decline, that is, from factors other than habitat destruction, habitat modification, and introduction of harmful non-native species.

Table 1. Arizona sites with high quality leopard frog habitat, without large populations of harmful non-native species (predatory fishes, bullfrogs, crayfish) where the Chiricahua leopard frog is absent or rare.

Locality	Habitat type(s)	Other Aquatic Species	Perennial Water?	Current CLF Status	Historic Records ?
Horseshoe Potholes, Chiricahua Mts.	Bedrock plunge pools	Canyon Treefrog, Red-spotted Toad	Probable	absent	No
Spring of Contention, Peloncillo Mts.	Bedrock stream	Canyon Treefrog, Sonoran Desert Toad	Yes	absent	No
Big Casa Blanca Canyon, Santa Rita Mts.	Bedrock plunge pools	Canyon Treefrog	Yes	absent	Yes
Cienega Creek, Empire Ranch.	Cienega-stream complex	Bullfrog, Longfin Dace, Gila Chub, Topminnow	Yes	rare	Yes
Hannigan Meadow, White Mts.	Natural wet meadow	Tiger Salamander	Yes	absent	Yes

There is an extensive record of major mortality events in Arizona leopard frog populations that predates the 1990's die-offs summarized below (Table 2). Tarahumara frog mass mortality events and declines were also observed at localities in northern Sonora (Hale and Jarchow, 1988; Hale and May, 1983; Hale, 2001). In Sonora, Tarahumara frog and big-eyed leopard frog (*R. magnoclaris*) specimens from as early as 1982 and 1985, respectively, have been found to carry the chytrid fungus pathogen (Hale, 2001), and this pathogen has been found in Tarahumara frog specimens found dead in Sycamore Canyon in Pajarito Mountains during the 1974 die-off that preceded extirpation of the species there (P. Fernandez and T. Jones, *manuscript*). Although *Batrachochytrium* was present in Arizona by 1974, Frost and Bagnara (unpublished field notes) recorded only two dead frogs during extensive and intensive, year-round studies of four species of leopard frogs in Arizona, with thousands of individuals observed and a study focus primarily in southeastern and east-central Arizona, where subsequent declines have been most pronounced.

Retrospective analyses of University of Arizona museum specimens (n=22) of the lowland leopard frog collected 1954-1987 in the cool season in southern Arizona yielded primarily negative results for presence of chytrid pathogen; and 4 from Sierra El Tigre (Sonora, Mexico) in 1982 were also negative, even though *R. tarahumarae* from there were dying-off at

the same time and 2 of the 3 available specimens were positive for chytrids. In contrast, 6 of 8 *R. yavapaiensis* collected from northern Sonora in 1999 tested positive for chytrids. Similarly, 5 specimens of apparently healthy *R. yavapaiensis* collected in Cienega Creek and San Pedro River during 1999-2000 all tested positive for the chytrid pathogen. The chytrid pathogen was certainly present in Arizona in the early 1980's but was not apparently as prevalent or as pathogenic in *R. yavapaiensis* as it subsequently became.

The first report I have of mass mortality in *R. yavapaiensis* is from 1985 (Table 2), although specimens from that event are not available for analysis. During 1972-1976, this species was extremely abundant in stock ponds in southeastern Arizona that are now occupied by *R. catesbeiana* and non-native fish (J. Frost, unpublished field notes); it also occurred in a number of relatively high-elevation and montane canyons (Sycamore Canyon, California Gulch, Big Casa Blanca Canyon, Gardner Canyon, Box Canyon, Adobe Canyon) where it was sympatric with *R. chiricahuensis* (J. Frost, unpublished field notes), probably having reached those areas during a heyday it was experiencing at the time. It has receded from all or most of these sites, perhaps due to a combination of metapopulation collapse associated with the spread of introduced species and to unobserved disease-related die-offs. I speculate here that the widespread overlap on the three leopard frogs in Arizona during the 1970's (Frost and Bagnara, 1977; Frost and Platz, 1983; Platz and Frost, 1984; Platz and Mecham, 1979; J. Frost, unpublished field notes) may have reflected metapopulation explosions into the favorable habitat of stock ponds prior to their elimination from most of those sites by later-arriving non-native species, as Hammerson (1982) described for Colorado. If this is true, I would suggest that at least some of the disappearances of *R. yavapaiensis* populations at higher elevations, especially where *R. chiricahuensis* has persisted or at least retained an occasional presence (i.e., Sycamore Canyon, California Gulch, Gardner Canyon, Box Canyon), represent natural losses associated with a competitive or other dynamic in suboptimal habitat for the species. Thus, Table 2 only lists the Sycamore Canyon decline for this species, since it was actually found to be abundant there (J. Frost, unpublished field notes for 26 August 1973).

In the museum sample of *R. yavapaiensis* from Arizona, the only frogs that tested positive for chytridiomycosis were 4 individuals collected at the swimming pool at Muleshoe Ranch (Mineral of Hooker's Hot Springs) in Hot Springs Canyon, Galiuro Mountains, Cochise County, Arizona. These specimens were taken by Steve Hale on 17 October 1985, and maintained in water acidified with nitric acid for 1-2 wk to test the idea that acid rain was responsible for unexplained ranid frog mortality he had observed in Arizona and Sonora (S. Hale, pers. comm.). The frogs did not appear to have become sick, and they were preserved on December 19, 1985. It appears most likely that the stress of living in plastic bags with acidified water triggered proliferation of the chytrid pathogen. Although this experiment was not tightly controlled against possible contamination with biological agents contacted during Hale's field surveys, there is no reason to suspect such contamination.

Taken together, the data from these various sources all suggest that an unknown stressor triggers chytridiomycosis, or its transmission, in *R. yavapaiensis*. In contrast, chytridiomycosis and die-offs in *R. tarahumarae* and *R. chiricahuensis*, which typically inhabit cooler sites at higher elevations than *R. yavapaiensis*, appeared earlier and apparently with greater severity. This may simply reflect the thermal dependencies of anuran immune function and of activity of the pathogen in an environment that was degrading in ways that we still don't understand.

Table 2. Sites where major die-offs and population collapses of ranid frogs have been observed in Arizona and New Mexico.

Locality	Species	Events Observed	Dates	Current Status	Sources
Sycamore Canyon, Pajarito Mts.	*R. tarahumarae*	spring die-off	1974	extirpated	Hale and May, 1983 Hale and Jarchow, 1988; Hale et al., 1995; Hale, 2001
Sycamore Canyon, Pajarito Mts.	*R. chiricahuensis*	unexplained decline, spring die-off	1970''s, 1990	uncommon	Hale et al., *op.cit.*; J. Carpenter, pers. comm.
Sycamore Canyon, Pajarito Mts.	*R. yavapaiensis*	unexplained decline	1970''s, 1990	extirpated	Hale et al., *op.cit.*.
Gardner Canyon, Santa Rita Mts.	*R. chiricahuensis*	unexplained decline	1972-1977	rare, or absent	Hale et al., *op. cit.*
Gardner Canyon, Santa Rita Mts.	*R. tarahumarae*	morality observed, April 1972.	1972-1977	extirpated	Hale et al., *op. cit.*
Big Casa Blanca Canyon, Santa Rita Mts.	*R. chiricahuensis*	overwinter population collapse	1977-1985	extirpated	Hale et al., *op. cit.*
Big Casa Blanca Canyon, Santa Rita Mts.	*R. tarahumarae*	overwinter die-offs	1977-1983	extirpated	Hale et al., 1995
Ciénega Creek at Empire Ranch	*R. yavapaiensis*	unexplained decline, dead frogs	1970 - 1996	extirpated	J. Frost, J. Simms, pers. comm.
Redfield Canyon	*R. yavapaiensis*	spring die-off	Mar.-June 1985	unknown	C. Schwalbe, pers. comm.
Hidden Water Spring, Mazatzal Mts.	*R. yavapaiensis*	die-off	Mar.-Apr.1988	recovered	C. Schwalbe, pers. comm.
San Luis Pass Tank, NM	*R. chiricahuensis*	unexplained extirpation	late 1980''s	extirpated	Scott, 1992
Cooney and Gillette Tanks, NM	*R. chiricahuensis*	overwinter population collapse	1988-9	extirpated	Jennings, 1995

II. 1990's Population Trends in Southwestern Ranid Frogs Affected by Chytridiomycosis.

Chiricahua Leopard Frog

Rana chiricahuensis monitoring results consistently show negative population trends when disease is detected (Figure 1). Further, unexplained, catastrophic mortality events apparently have produced sudden population extinctions in this species across significant areas of New Mexico (Jennings, 1995; Scott, 1992; Scott, 1993). Some of our results are similar, although others show less catastrophic outcomes. For example, at Belency Tank, Magoffin Ranch, as in New Mexico, we observed the rapid decline and loss of an apparently successful population inhabiting a stock pond. The disappearance was sudden, with apparently good numbers of individuals during late summer in 1996, followed by the appearance of a single dying frog in the autumn, with no subsequent observations of frogs at the site for four years. In late summer of 1996, 15 adult frogs that we believe came from Belency Tank were found about 3.5 km north of the tank in summer rain pools (in Hay Hollow, at Cocklebur Crossing of Guadalupe Canyon Road, on Magoffin Ranch), and some of these were collected and held at Magoffin Ranch headquarters and then at the SBNWR ranarium. These frogs died unexpectedly, and chytridiomycosis was confirmed at cause of death (Bradley et al., 2002, *in press*). Thus, chytridiomycosis was probably involved in the disappearance of this stock tank population.

Secondly, we monitored and managed the stock pond population at Rosewood Tank, where despite severe conditions a nucleus of frogs persisted and reproduced through the locally severe and extended drought of 1993-1999 (Fig. 1; Appendix). At this site the only decline was obviously tied directly to the drying of the tank in 1993 and 1994. Sick or dead frogs were never observed, and it was apparent that large, olive-colored individuals survived for at least 4 or 5 yr at the site. A somewhat similar situation has developed at Douglas High School (DHS; Fig. 1; Appendix), where individuals reared from eggs (which came Rosewood Tank stock) were released in a small pond on campus in 1997, and have flourished since then. At this site, also, in 2000 and 2001, large olive-green individuals were seen that appeared to represent long-term survivors, although here they were mixed with smaller, emerald green adults that evidently represent 1+ yr or 1-2 yr old age classes. Large numbers of frogs were present at DHS: counts of up to 50 represented only a fraction of individuals that could have been seen if obstructing vegetation was not there. At DHS, a total of 11 dead individuals have been observed by students and teachers who are often on-site; some of these had apparently been injured by local cats or other animals, and none of the 9 specimens analyzed histologically showed evidence of chytridiomycosis or other microbial disease. Thus, it appears that at Rosewood Tank and DHS, for unknown reasons, chytridiomycosis has not developed, and as a consequence the populations have been relatively stable.

A third type situation may occur in the natural population at Leslie Canyon (Fig. 1). This population was large and healthy in the 1970's (J. Frost, field notes, with a mean of about 57 frogs seen per visit), 1980's (Rosen and Schwalbe, 1988), and even through most of the 1990's, until winter 1997. In winter 1997-1998, one lethargic and one dead frog were found, and by the next spring, the population had collapsed to a low level at which it has remained 1997-2001 (Fig. 1; Appendix). None of the dead frogs, which were seen every subsequent winter except for 2000-2001, were suitable for histological analysis, and a large adult I caught in July 1998, which at first seemed slow, gave negative results for chytrids in skin scrapings, and was evidently healthy under quarantine. However, in 1999 Nina King held several Leslie Creek frogs in isolation at nearby SBNWR headquarters, in the Sulphur Springs Valley, and all of these frogs died overwinter. One specimen was submitted to VDL and found to have evidence of chytridiomycosis. Thus, it appears that the decline at Leslie Creek is also associated with, and perhaps caused by, chytrid fungal disease. Nonetheless, results for Leslie Canyon suggest that *R.*

chiricahuensis may be able to persist despite disease and associated population decline. A similar result is suggested for the SBNWR exclosure population (Fig. 1), in which specimens suitable for histology could not be obtained to confirm chytridiomycosis, although that was probably the disease involved in the observed decline.

While there is some evidence for stressors associated with some of these die-offs, it is not yet compelling. In the exclosure, a remarkably high population density was achieved in 1996 (Fig. 1), and late in that summer, immediately preceding the population collapse, the frogs appeared thin, rather than plump as seen the previous 2 yr. This somewhat resembles a situation in *R. yavapaiensis* at Cienega Creek, in which sick and dead frogs sometimes appear to be thin and lean (pers. obs., 1995). At Leslie Canyon, frogs are not often seen at close range, and no information is available on condition or health prior to the die-off. However, 1998 was a year of severe drought, and it is possible that flooding and drought had an effect that was manifested as disease. Although I don't find this compelling, it is true that during 1998-2001 Leslie Creek did not appear as lush and healthy as it did previously, if memory serves me properly. During recent years, the watercress and other submergent vegetation have usually been sparse, and reddish and yellowish growths of alga or fungus have been conspicuous. As might be expected, the black-necked garter snake population at Leslie Canyon (*Thamnophis cyrtopsis*) has quite obviously declined since 1997. The primary, and more tractable, question remains: will continued monitoring reveal that this population does, in fact, persist?

During the SAWAMP wintertime disease monitoring work, additional *R. chiricahuensis* populations were visited to investigate disease occurrence. At Cienega Creek (Empire Ranch) and Deer Creek (a single visit only; Galiuro Mountains) only live frogs were observed during winter and no evidence of mortality or disease was seen. The lack of evidence for mortality at Empire Ranch is surprising, as that is a site where leopard frogs (*R. chiricahuensis, R. yavapaiensis*) were abundant at least as recently as 1975 (Frost and Bagnara 1977; Frost and Platz, 1983; Platz and Frost, 1984; Platz and Mecham, 1979; Platz and Platz, 1973; John Frost, field notes). Now only *R. chiricahuensis* and *R. catesbeiana* occur there, and both are uncommon or rare, and localized. It seems improbable that the few bullfrogs in evidence are directly responsible for the rarity of leopard frogs. Furthermore, there is no obvious explanation for the rarity of *R. catesbeiana*, although low water temperatures and lack of warm pond environments could be contributory factors. Dead frogs were seen at Cienega Creek in the early 1990's during intensive fish sampling (Jeff Simms, pers. comm. 1996), so it is possible that the lack of recent evidence for disease is an artifact of disease-related rarity and difficult visibility conditions for observers at the site. Additional investigation of wintertime frog health, and year-round frog population processes appears warranted at this Ciénega Creek.

At Sycamore Canyon, Pajarito Mountains, in winter 1999-2000, 2 of 3 *R. chiricahuensis* found dead were determined to have chytridiomycosis. This is consistent with earlier-observed catastrophic mortality events affecting ranid frogs at this site, and suggests a possibility that *R. chiricahuensis* may persist, albeit in reduced abundance, at some sites affected by chytridiomycosis. The situations at Cienega Creek and Leslie Canyon may well turn out to be additional examples of this. Why this has not been seen in stock ponds is entirely unclear.

In summary, the evidence from Cochise, Santa Cruz, and Pima counties demonstrates that chytridiomycosis is present in *Rana chiricahuensis* and is found in association with marked and severe population declines. Whether any infected populations will survive over the long term remains to be determined, and is the key question. The role of additional stressors, if any, in the disease process is a second important, unresolved question.

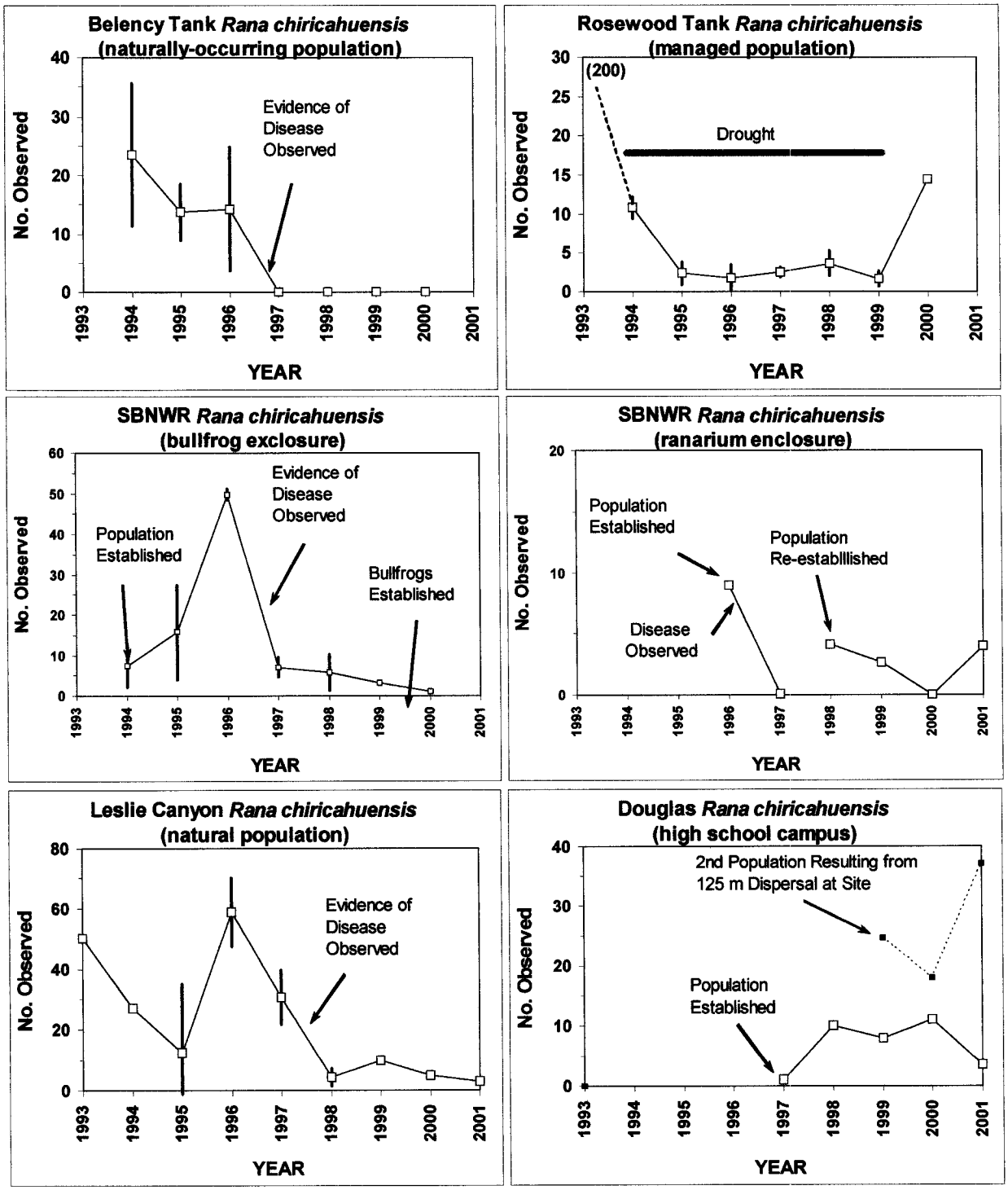

Figure 1. Population processes at study localities for the Chiricahua leoaprd frog at and near San Bernardino / Leslie Canyon National Wildlfe Refuge, with management history and observations of disease (dying or lethargic frogs). Histological results showed evidence of chytridiomycosis associated with population declines and extinctions illustrated here.

Lowland Leopard Frog

Rana yavapaiensis monitoring results (Table 3) are less clear in associating declines with disease, although they were collected in less consistent fashion than the results for *R. chiricahuensis*. It appears that immediate population declines may not necessarily accompany the appearance of chytridiomycosis and die-offs in this species. For example, at Cienega Creek County Preserve, at and below Pantano (Marsh Station), cool-season mortality events have been observed since 1995 (except in 1996, when limited work was done), with confirmation of involvement of chytridiomycosis obtained for 1996-7, 1998-9, and 1999-2000 (Table 3; Appendix). High summer densities have been confirmed for 1986 and 1994 (pers. obs.), 1996 and 1997 (Bill Peachy and Don Carter, pers. comm.), and 1998-2000 (Robin Lawson, D. Caldwell, pers. comm.; Appendix). However, for the first time, in summer 2001, no summer flush of young frogs was seen. In previous years, observed numbers dropped rapidly after September (as also seen at Agua Caliente Canyon by Sartorius and Rosen [2000]). This overwinter decline may be partly caused by predation, but the population dynamics involved remain to be investigated. At Agua Caliente Canyon, black-necked garter snakes (*Thamnophis cyrtopsis*) were abundant, and at Cienega Creek tracks of predators (great blue herons, green herons, feral domestic cats, raccoons, and skunks) have been seen abundantly around pools occupied by frogs before the annual decimation. Closer examination of population processes will be required for a proper understanding of the roles of chytridiomycosis and other causes of mortality in the seasonal and long-term population changes of *R. yavapaiensis*.

Decline of *R. yavapaiensis* at Big Spring (Sredl et al., 1997a) and at Cottonwood Creek near Lake Pleasant (Jones, 1998; Weimann and Jones, 2000) are associated with diagnoses of chytridiomycosis, and in both cases severe numerical decreases of frog abundances were observed. However, in each case the disease and decline was also associated with floods that markedly degraded habitat quality by removing vegetation and filling the best pools with sand.

Chytrid-associated die-offs of *R. yavapaiensis* have also been documented in Arizona at Blue River (Greenlee County), Rock Creek and Mesquite Wash (Maricopa County), and in northern Sonora, as well as at numerous localities throughout the species' range in the Tucson region and southeastern Arizona (Appendix; Hale, 2001). In southern Arizona, the disease organism has been confirmed in this species at Montrose Canyon, Tanque Verde Canyon, Chimenea Canyon, Cienega Creek County Preserve, lower San Pedro River, Paige Creek, Buehman Canyon, Aravaipa Creek, and Bass Canyon. Other than at Aliso Spring and small, relatively isolated population sites in Saguaro National Park, the localities from which it has not been found (Romero Canyon, Sabino Canyon, Agua Caliente Canyon, Tar Wash and Tucson Wash tanks in the northeastern Santa Catalina Mountains) have not yet been adequately investigated. As described below, there may be exceptional populations where the disease organism or disease is absent, but it is clear that chytridiomycosis occurs essentially range-wide in *Rana yavapaiensis*, and has been present since at least 1983.

Table 3. Mean number of observed frogs per survey, number of surveys, and total number found dead during disease-monitoring studies of lowland leopard frog (*Rana yavapaiensis*) populations in the area of Tucson, Arizona, 1995-2001.

Locality	Year						
	1995	1996	1997	1998	1999	2000	2001
	I. Site Without Observed Chytridiomycosis or Die-offs						
Aliso Spring	*mean =*			2.5	8.5	4.2	11.0
	n =			*n=2*	*n=2*	*n=6*	*n=3*
	(#dead =)			(0)	(1)	(0)	(0)
	II. Site With Chytridiomycosis but no Observed Die-offs						
Saguaro Nat'l Park		6.0			30.3	12.5	7.0
		n=1			*n=4*	*n=11*	*n=2*
		(0)			(1)	(4)	(0)
	III. Sites With Chytridiomycosis and Associated Die-offs						
Buehman Canyon				2.0	39.0	28.0	2000
				n=1	*n=3*	*n=5*	*n=1*
				(2)	(9)	(21)	(0)
Cienega Creek	12.0	55.0	26.0	2.0	18.1	12.9	4.3
	n=1	*n=2*	*n=4*	*n=1*	*n=9*	*n=30*	*n=6*
	(5)	(0)	(3)	(2)	(3)	(24)	(1)
lower San Pedro R. basin	3.4				1.0	4.8	
	n=7				*n=1*	*n=6*	
	(0)				(1)	(5)	
Montrose Canyon					37.5	5.0	6.0
					n=6	*n=4*	*n=1*
					(133)	(10)	(0)
	IV. All Sites						
	4.5	38.7	26.0	2.3	25.8	11.9	159.9
	n=8	*n=3*	*n=4*	*n=4*	*n=25*	*n=62*	*n=13*
	(5)	(0)	(3)	(4)	(148)	(64)	(1)

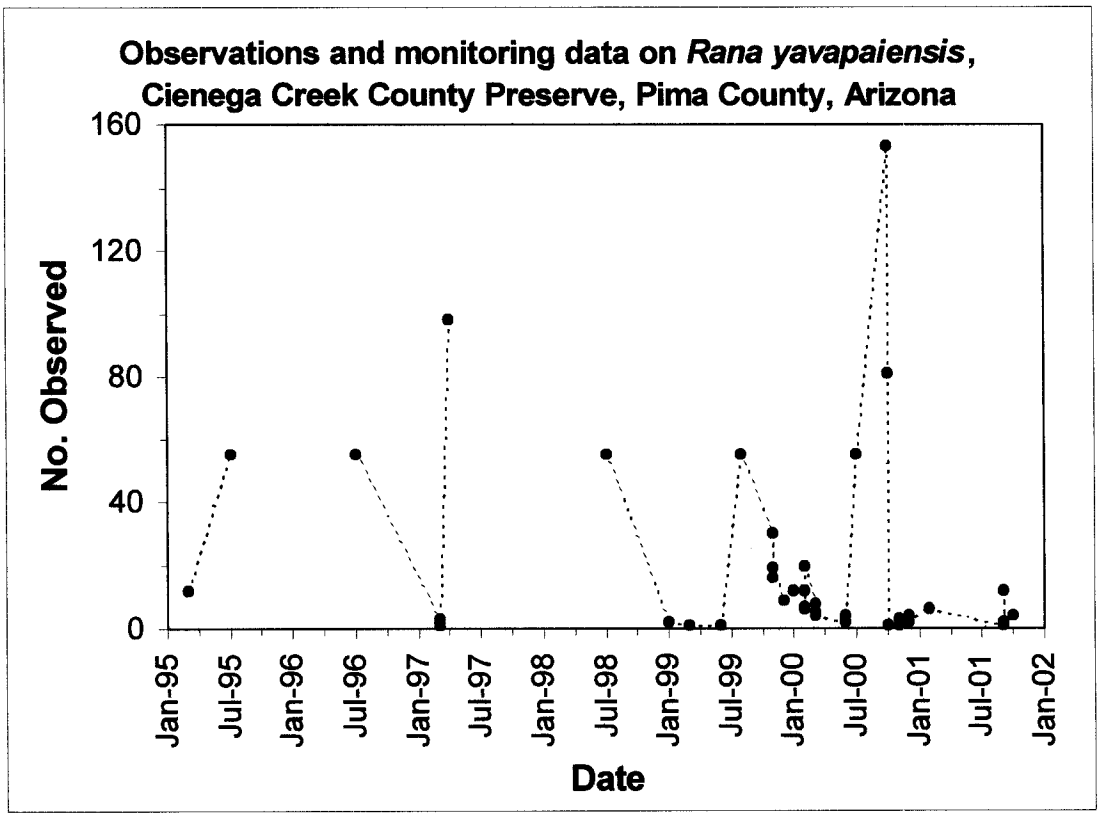

Figure 2. Annual fluctuation pattern of the lowland leopard frog at a major population site in southern Arizona. The counts reported were collected during work with other focus; reports of dense populations were arbitrarily assigned a value of 55 based on previous experience with what such an observation implied. Mortality events were observed in each year that cool-season surveys were conducted, and chytridiomycosis was confirmed as a cause of cool-season mortality beginning with specimens from 1997, when the disease was first discovered.

Bullfrog

Rana catesbeiana has been confirmed to carry chytridiomycosis at SBNWR, based on histological findings from a juvenile and a tadpole collected in 1999 and 2000. The infected animals were collected because they appeared to be unhealthy, whereas other specimens from SBNWR, Cienega Creek, and San Pedro River, which did not appear unhealthy, had no histological evidence of the chytrid pathogen (Appendix). Dozens of dead juvenile bullfrogs were observed by refuge personnel at SBNWR during winters in the 1990's (M. Magoffin, K. Cobble, pers. comm.), and dead and obviously sick bullfrog tadpoles were seen in both winter and summer. However, no adult or subadult (or, large juvenile) bullfrogs were found dead or obviously sick. Despite the presence of disease, and our efforts to eliminate bullfrogs at SBNWR (Rosen and Schwalbe, 2002, this report), the bullfrog population at SBNWR remained robust through the 1990's (Fig. 2), and thereafter. There was also a lack of evidence for bullfrog declines in Cienega Creek (where they appear to be increasing [D. Caldwell, pers. comm.]), or lower San Pedro River (where they have been, and remain, relatively uncommon, probably due to unsuitability of the habitat [Sartorius and Rosen, 2000]).

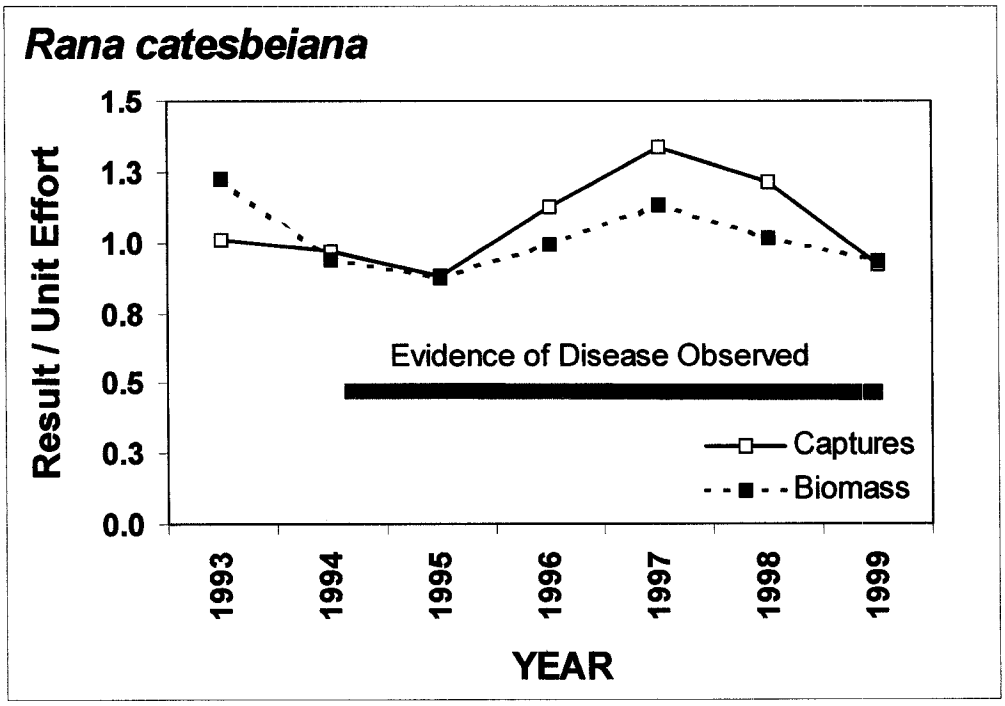

Figure. 3. Bullfrog population trajectory during intensive removal efforts at San Bernardino National Wildlife Refuge, Cochise County, Arizona, 1993-1999. Histological results on juvenile and larval individuals collected when they appeared sick yielded evidence of chytridiomycosis. Die-offs of juveniles were observed during the cool seasons of the mid-late 1990's, and larvae were found dead or with discolored skin patches at various times of year.

Discussion

The evidence presented in Tables 1 and 2 shows that unoccupied leopard frog habitat and unexplained declines among native ranid frogs in Arizona and adjoining New Mexico were widespread phenomena, both taxonomically and geographically. It appears that leopard frogs suffered disappearances or significant declines at some major population sites over a wide area in Arizona, possibly paralleling the extinction of the Tarahumara frog in the Arizona part of its range during 1974-1983 (Hale et al., 1995; Hale, 2001). Similar declines and mortality events have continued to be reported subsequently, including in 1993-2001, when they were observed more closely. In each case where suitable material was available for histological analysis, *Batrachochytrium*, the infectious agent (Longcore et al., 1999; Nichols et al., 2001) in the newly identified disease chytridiomycosis (Berger et al., 1998), has been found in dead frogs collected at mortality sites. This disease has now been found in all 6 ranid frog species in southern Arizona (Bradley et al., 2002, *in press*; this study), and generally appears to be the only or the primary cause of death when it is found (Bradley et al., 2002, *in press*). There seems little doubt that it is the proximate cause of mortality in these events, yet there is some evidence to suggests that its lethality may be enhanced by environmental stresses that have not been identified.

The geographically broad occurrence of chytridiomycosis in *Rana yavapaiensis* may be a product of the abundance of the frog and its relatively continuous distribution along inter-connected lowland and canyon stream systems, which would facilitate intraspecific transmission of the disease. Furthermore, the lowland leopard frog can persist in proximity to *R. catesbeiana* in Arizona (at least in relatively intact desert stream environs [Nelson and Rosen, 1996; Sartorius and Rosen, 2000; Rosen and Schwalbe, 2002, *in press*]). If the bullfrog is the original vector for entry of *Batrachochytrium* into the Southwest, or if it simply serves as a disease reservoir, its wide distribution in valleys where it has replaced *R. yavapaiensis*, and its contact via dispersal with now-isolated *R. yavapaiensis* populations, would further facilitate the spread of chytridiomycosis in *R. yavapaiensis*.

The only study site southern Arizona where it may be suspected that chytrid pathogen is absent is Aliso Spring in the Tumacacori Mountain. Like other sites where major disease-associated die-offs have not yet been observed (sites in Saguaro National Park, and at Mineral Hot Springs in Hot Springs Canyon), it is a warm site. The bajadas and lower slopes of the Tumacacori Mountains are renowned for lack of winter cold, such tropical species as wild chile pepper and the brown vine snake persisting, while the lower slopes on the south face of the Rincon Mountains in Saguaro National Park are renowned for penetration of such tropical species as *Lysiloma microphylla* and high-elevation populations of the desert tortoise (*Gopherus agassizii*). At Hooker's Hot Springs (Muleshoe Ranch) in 2000, the largest concentration of *R. yavapaiensis* was found in the outflow from the hot tubs and hot pools. Here, winter warmth may offer a measure of protection against the effects of *Batrachochytrium*, even though it has been recorded both at Chimenea Canyon (the primary frog population at Saguaro National Park) and in a dead frog found in Bass Canyon near Mineral Hot Springs. This association of winter warmth and healthy persistence of native leopard frogs was also seen in New Mexico (Jennings, pers. comm., 2000), and is consistent with thermal aspects of the epidemiology of this disease (Berger et al., 1998; Longcore et al., 1999; Nichols et al., 2001; Piotrowski et al., 2001).

An additional factor in local persistence of lowland leopard frog numbers might be isolation from bullfrogs and humans with muddy footgear that could transit the pathogen to *R. yavapaiensis* localities. Aliso Spring is one of the least-known, difficult-to-access population sites for leopard frogs, and it is not close to known, large bullfrog populations. Chimenea is highly inaccessible to people, but is within dispersal contact distance of bullfrogs that occur in gravel pit operations on Pantano Wash above Houghton Road (pers. Obs., 2000-2001; D. Suhre,

pers. comm., 1999) and, more recently, in golf course developments at the lower end of Cienega Creek (D. Caldwell, pers. comm., 2000). Chimenea frogs may also contact leopard frogs from Cienega Creek that could transmit disease to them. Thus, it may not be surprising that the pathogen has been found recently at Chimenea. Other study localities at Saguaro National Park are smaller and drier than Chimenea, and most are quite isolated, even from irregular contact with other frog populations. The absence of chytrid there, if real, may reflect simple isolation.

In summary, for *Rana yavapaiensis*, resistence to chytridiomycosis may be related first to winter warmth – both at exceptional sites and for this lowland desert species as a whole – and secondarily to isolation from sources of infection.

For *R. catesbeiana*, we can speculate that the evident resistence to population decline despite presence of the chytrid pathogen may have two underlying causes. First, chytridiomycosis probably arrived from eastern North America, where large anuran populations, including *R. catesbeiana*, may have successfully evolved resistance to the disease before its arrival in the West. Second, subadult and adult *R. catesbeiana* in Arizona study populations may be robust and thus able to resist or survive the disease because of their size or the scarcity of ecological stressors for them in the novel environment. This will be a difficult issue to resolve. However, the observed facts that this introduced species can be a carrier of disease, quite likely with few or no symptoms, indicates that this species is a vector for chytridiomycosis, and one that will ensure dispersal of the disease across large areas in which it has supplanted native ranid frogs. *Rana catesbeiana* was stocked into Pena Blanca Lake in 1968 (3,000 larvae) and 1971 (5,000 larvae; AGFD stocking records), quite close to the population of *R. tarahumarae* that, in 1974, became the first known victim of chytridiomycosis in the Southwest.

Indeed, the absence of reports of chytridiomycosis in Africa, and the resistence to this disease in the African clawed frog (*Xenopus laevis*), suggests an African origin with original transmission to North America in *X. laevis* imported for research. These frogs would inevitably have somehow contacted wild frogs, spreading disease through eastern North America, where major die-offs were actually observed in the early 1900's (Reichenbach-Klinke and Elkan, 1965, pp. 233-4). Frogs are (and were) so numerous in the east that we might predict that disease resistence could have occurred prior to extinctions. The subsequent spread of the disease to the West may well have been accomplished by introduction of *R. catesbeiana*. This hypothesis seems preferable to one in which the disease spread through the northern leopard frog (*R. pipiens*) from east to west, because that species is not continuously distributed and should have evolved its own resistence and thus not have suffered the massive declines it did in Arizona (Sredl et al., 1997b) and New Mexico (see Degenhardt et al., 1996). It is also worth remarking that *Xenopus laevis* was definitely introduced into a number of ponds in the Pajarito Mountains in 1960, including in Alamo Canyon where contact with the now-extirpated population of *R. tarahumarae* would have been possible. We should note, however, that there is no evidence that these introductions yielded even temporarily persistent or reproducing populations. Perhaps these hypotheses can be evaluated as our knowledge of the biology of this disease grows.

Chytrid fungus disease appears to pose a significant threat to *Rana chiricahuensis*. Evidence presented here indicates that most or all infected populations fare poorly. This leopard frog has already been so severely affected by introduced species that it will probably be listed in 2002 as a Threatened Species under the U.S. Endangered Species Act (see USFWS, 2000). It has been eliminated from most of it former strongholds in grassland valley cienegas (Rosen et al., *manuscript*; Rosen and Schwalbe, 2002, *in press*), and now exists in small populations, almost all of which are isolated from sources of gene flow or recolonization (see Sredl and Howland, 1995; Sredl and Saylor, 1998). Although these populations isolated from one another, they are unlikely to remain permanently isolated from disease vectors such as dispersing *R. catesbeiana*

or *R. yavapaiensis*. Such small and isolated populations have limited opportunity and potential to evolve disease resistence to a novel pathogen before it wipes them out.

There is substantial inertia, and even resistence, facing current efforts to recover populations of the Chiricahua leopard frog. It faces severe threats from both introduced species and chytrid fungus disease, and its already precarious existence can be predicted to become even more tenuous. For political reasons, it seems unlikely that either the State of Arizona nor the U.S. Fish and Wildlife Service will be able to take decisive action in the foreseeable future to reverse the decline of this species. There are three or four avenues that could be pursued to recover the Chiricahua leopard frog.

First of all, it is essential that the species be restored to at least its former numerical abundance, which will give it the potential to evolve disease resistence. One element of this would likely need to be re-establishment of the Chiricahua leopard frog in critical areas of its original habitat, from which it is now absent, and a second element would likely be re-establishment of the species in ranch ponds and/or elimination of ranch ponds and other artificial waters as sources of biological pollution. These elements would require active cooperation from cattle ranchers and golf-course and housing developers, as well as strong enforcement and active recovery efforts from AGFD and USFWS. At present, there is no evidence to suggest that a single one of these requirements are being, or soon will be, met.

Second, the Chiricahua leopard frog may be successfully propagated in ranaria as was done at SBNWR (Rosen and Schwalbe, 2002, *this report*) and at Grand Canyon University (Fernandez, 1996). Experience suggests that the frog breeds well and is hardy in this setting. Analogously, small backyard ponds and schoolyard ponds could serve as reservoirs of the species in towns and cities. The results presented here for the Douglas High School ponds suggest that this is biologically feasible. In larger cities, bullfrogs may not be abundant or successful at dispersal, and may not foreclose this low tech conservation option, which they may in smaller towns and rural settings. A principal obstacle here, though, is refusal of either AGFD or USFWS to release sensitive species to the public for propagation and enjoyment. The absurdity of these policies is only heightened when one realizes that the eventual result is propagation, and at least occasional release, of harmful non-native frogs and fishes. Although many workers in these agencies fully recognize this, it is not clear that they have enough strength to move the boulder.

Third, basic research may reveal unpredicted solutions to the problems of disease and non-native competitors and predators that afflict the Chiricahua leopard frog. For example, toxins or other agents may be found that can eliminate non-native bullfrogs or crayfish as readily as rotenone and antimycin can eliminate fish. Active experimentation with toxins might be appropriate, but it should be recognized that most toxins will be broad-spectrum – affecting too many taxa to permit their use in key natural environments. Certainly, for instance, no toxin that kills fish or starves them by eradicating their prey is likely to be applied at such a key site as Sycamore Canyon in the Pajarito Mountains, where the threatened Sonora chub (*Gila ditaenia*) lives.

Another example of potential research-based progress is the possibility that a means of curing key diseases or planting genetic resistence to them may be discovered. Expanding our knowledge and understanding of chytridiomycosis (see e.g., Rollins-Smith et al., 2002b, 2002a *in press*) in ranid frogs is certain to help us understand and, potentially, reverse the decline of the Chiricahua leopard frog. While money for research doesn't quite grow on trees, at least funding of such research doesn't face the possibly intractable obstruction of active conservation measures that is currently evident in Arizona, and elsewhere.

Recommendations for Management and Research

1. Monitoring of population trajectories and disease mortality should continue at key localities: Cienega Creek County Preserve, Empire Cienega, Sycamore Canyon (Pajarito Mountains), Montrose Canyon, Chimenea Canyon, Aliso Spring, Leslie Canyon, Douglas High School, and Magoffin Ranch. Although outside the study region for this report, the same applies to Cottonwood Creek (Lake Pleasant area) and Big Spring.

2. One or more key sites for each species (*Rana chiricahuensis, Rana yavapaiensis*) should be selected for more in-depth investigation of population processes. Obvious choices for these sites are Cienega Creek County Preserve, Empire Cienega, Sycamore Canyon (Pajarito Mountains), Chimenea Canyon, and Leslie Canyon. There are key unknowns regarding overwintering sites, drought refugia, survivorship, sources of mortality, and dispersal phenomena that are essential to conservation biology and management issues for these frogs.

3. Organized study of disease, demographics, and dispersal in bullfrogs in Arizona is needed and should be funded. Know thine opponent.

4. Basic research in amphibian disease should be funded, and attempts should be made to focus this research on species occurring here, or in whatever area the research is being conducted. This will greatly increase the likelihood that ecologically relevant results will become available, and will foster essential interactions between field and laboratory practice and practicioners.

5. The process of listing the Chiricahua leopard frog as a Threatened Species under the Endangered Species Act should be completed promptly. Keeping the species in limbo, as it has been, is holding up funding and inhibiting political decision-making.

6. Active approaches to improving regional status and population status in the Chiricahua leopard frog (and other native ranids) should be approved and carried out more swiftly and decisively than they currently are by responsible agencies, including AGFD. Waiting for things to get worse or actually blow up, while perhaps our way, is totally unjustifiable. We learn as much conservation biology and general natural history by monitoring active management as we learn by any other method, to say the least.

7. Development of captive (ranarium, backyard, schoolyard) populations of native Southwestern ranids should be encouraged and facilitated. These populations should, where appropriate, serve as study microcosms to observe demographic processes, disease processes, and effects of intra-specific inbreeding and outbreeding, as well as sources of material for experimentation or possible re-establishment, and may serve as reserves of genetic diversity.

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STATUS REPORT ON THE CHIRICAHUA LEOPARD FROG (*RANA CHIRICAHUENSIS*) IN THE SAN BERNARDINO VALLEY AND DOUGLAS REGIONS, COCHISE COUNTY, ARIZONA, WITH AN ANALYSIS OF REGIONAL HABITAT CONDITIONS FOR THE SPECIES

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ABSTRACT

We previously presented correlative evidence (Rosen and Schwalbe, 1995, 1998a, 2002 *in press*; Rosen at al., 1995) that introduced (non-native) vertebrates were a primary cause of recent declines of the Chiricahua leopard frog (*Rana chiricahuensis*). This frog species persists almost exclusively at sites lacking non-native species, which are widespread and abundant in Arizona. In southeastern Arizona, the bullfrog (*Rana catesbeiana*) appeared to be the most harmful species, although several larger predatory fishes, especially centrachids, also were identified as harmful.

Rana chiricahuensis has declined or disappeared in all original valley bottom ciénega strongholds and major mountain streams. It is now confined to small, unpredictable waters, greatly increasing its probability of extinction. It is gradually being replaced by the bullfrog in lakes and larger stock ponds. In large, deep, fully perennial waters, bullfrogs find optimal habitat conditions. In and near natural habitat types, habitat modification – normally in the form of impoundments – may facilitate the impact of bullfrogs on Chiricahua leopard frogs. Limited evidence points toward an ability of the Chiricahua leopard frog to persist despite the bullfrog in some unmodified ciénegas and streams. Nearby stock ponds that are semi-perennial may facilitate such co-existence, whereas perennial ones are likely to inhibit it. These ideas require further observations and more rigorous testing.

We surveyed the ranid frogs of the San Bernardino Valley-Douglas, Arizona region and established a conservation program there during 1993-2001. We used a series of bullfrog-free sites, or sites where we attempted to control or exclude bullfrogs, as re-establishment sites for the Chiricahua leopard frog. A number of sites had bullfrogs, which have proven difficult to control (Rosen and Schwalbe, 2002, *this report*), thus producing an experimental design allowing us more directly to evaluate the effect of the bullfrog. There was no evidence of successful establishment or persistence of *R. chiricahuensis* in 8 sites with bullfrogs. For 11 re-establishments without bullfrogs, we observed *R, chiricahuensis* persistence for a mean of 2.4 $\pm$ 0.39 SE yr, and for all 14 observed populations without bullfrogs mean persistence time was 3.5 $\pm$ 0.70 SE yr. These results add experimental support to the strong correlative evidence demonstrating the strong impact of non-native species.

In addition to presumed bullfrog predation and competition, re-establishment populations apparently failed due to disease (n=2), failure of artificial water supply (n=3), and unknown causes (n=1), and the history of one was not monitored. Five re-establishment sites remained successful through 2001 and three more were extant due to release of additional larvae in May 2000. Among natural populations, one failed in 1994 during drought, one drought-stricken population was managed successfully starting in 1994, one was lost due to disease, and one has persisted despite the appearance of disease and marked decline in frog abundance. The phalanx of factors assailing leopard frog populations is diverse, complicating recovery efforts. The tendency for populations supported by an artificial water source to succumb to temporary habitat desiccation, which occurred for a variety of reasons, should be noted. Counterbalancing this, the relative freedom that agencies gave the public to translocate eggs and tadpoles, as perceived need and availability of material arose, has resulted in the existence of at least 7 re-established populations as of this writing.

INTRODUCTION

Essentially all of the native ranid frog species (genus *Rana*) of western North America are in decline (Vial and Saylor 1993, and therein; M. Jennings 1995; Sredl and Howland 1995) or have disappeared (Hale et al. 1995; Stebbins 1985). The Chiricahua leopard frog (*Rana chiricahuensis*) is currently proposed for listing as threatened under the U.S. Endangered Species Act (U.S. Fish and Wildlife Service 2000). It was formerly abundant in our study region, and has suffered dramatic population declines throughout its range in the United States (Clarkson and Rorabaugh 1989; Sredl and Howland 1995; R. Jennings, C. Painter, personal communications) that are thought to result from introduction of non-native predators or competitors (Rosen and Schwalbe, 1995, 1996, 2002, *in press*), disease (Bradley et al., 2002 *in press*; Rosen and Schwalbe, 2002 *this report)*, and desiccation attendant to niche deterioration (Rosen et al., 1995). In this report, we discuss the habitat characteristics affecting the persistence of this frog, and we present results from what might be called a "conservationist's experiment": testing a hypothesis of decline by using it in practice for restoration. We attempted re-establishment of the CLF under conditions with and without non-native bullfrogs to explore the feasibility of active efforts for this species' recovery.

STUDY AREA AND SPECIES

This study was conducted in the semi-arid desert grassland and Madrean woodland of southeastern Arizona (Brown 1994) in an area encompassing the geographic range of the Chiricahua leopard frog in southern Arizona (Fig. 1; see Stebbins 1985). At its lowest elevations, this region supports Sonoran and Chihuahuan desertscrub. Desert grades into desert grassland at about 1000 m elevation, which in turn grades into oak woodland at around 1600 m, although in some areas Chihuahuan desertscrub is also interposed between grassland valley floors and the desert grassland and Madrean woodland of lower mountain slopes.

Permanent streams and marshy ciénegas (which are valley floor wetland-spring-stream complexes; see Hendrickson and Minckley, 1985) occur on each valley bottom in the region except the Sulphur Springs and San Simon. There are small perennial streams in Madrean oak-pine habitats in the Chiricahua, Huachuca, Santa Rita, and Pajarito mountains. Streams are disjunct from valley floor wetlands except during brief floods; intervening bajadas (broad, alluvial skirts) largely lack natural perennial waters. Other mountain ranges in the area have only tiny springs and semi-perennial streams, and correspondingly lack native fish (Minckley, 1973). Stock ponds ("tanks") constructed for cattle, primarily during the past century, occur throughout

the area. They are usually less than 0.5 ha in size and vary in maximum depth from ca. 1-5 m, are watered by storm water runoff, wells, or springs, and vary from ephemeral to perennial. Most stock ponds fill quickly after major rains, and lose water gradually by evaporation, infiltration, and consumption by livestock. There are five large artificial lakes in the region, constructed for sport fisheries.

The Chiricahua leopard frog is a moderately large (sometimes exceeding 100 mm snout-vent length) ranid frog inhabiting primarily perennial streams, springs, and marshes (Frost and Bagnara, 1977), as well as stock ponds (Scott and Jennings, 1985; Sredl and Saylor, 1998), in southeastern Arizona and southwestern New Mexico (R. Jennings and Scott, 1993). Its range continues south in Mexico along the Sierra Madre Occidental to central Durango (Platz and Mecham 1979; Stebbins 1985), with a disjunct occupied area in the mountainous region of central-eastern Arizona and adjoining New Mexico. Within inhabited stream or spring systems, this frog is frequently associated with the deeper pools. It has been found at all major valley bottom springs and streams in the desert grassland and woodland of southeastern Arizona, including San Bernardino National Wildlife Refuge (SBNWR), Whitewater Draw, San Pedro River, Santa Cruz River, Cienega Creek, Arivaca Creek, and Altar Valley (Clarkson and Rorabaugh, 1989 and therein; personal observations), often in great numbers (Wright and Wright, 1949; Frost and Bagnara, 1977). It has declined markedly in the last two decades (Clarkson and Rorabaugh, 1989; Sredl, 1997).

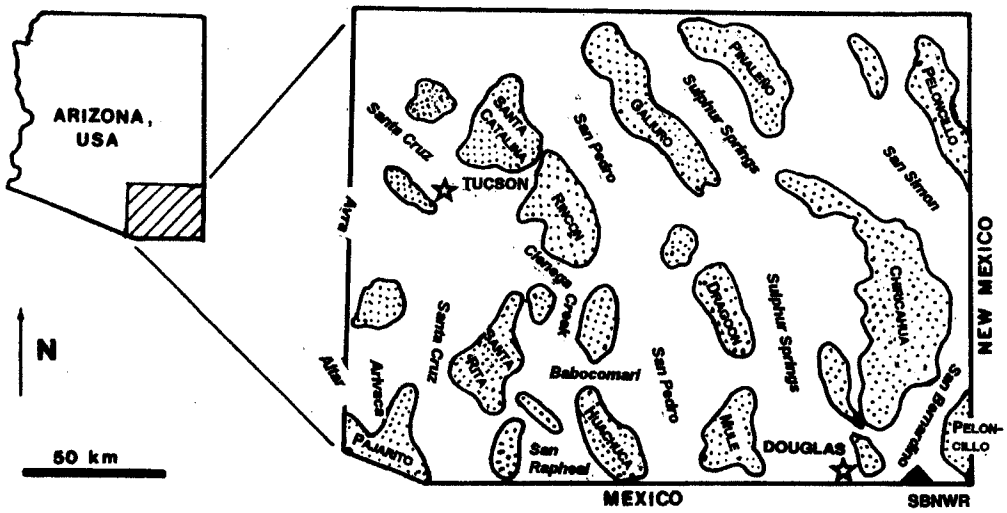

Figure 1. The study region in southeastern Arizona, USA, showing mountainous areas (stippled) and valley names (italicized).

METHODS

Surveys

We surveyed intensively for leopard frogs in southeastern Arizona in 1993-5, focusing during the drought summer of 1994. Focal areas were in the Chiricahua Mountains and surrounding valleys and the Buenos Aires National Wildlife Refuge region in Altar Valley. We additionally surveyed in the Pajarito Mountain complex and Santa Rita Mountains and surrounding valleys: in these regions, we focused at and near historically known localities where leopard frogs might most likely persist. During 1996-2001, we and others have continued to observe and monitor leopard frog populations throughout southern Arizona. Previously unknown, small population sites for native leopard frogs continue to be discovered in southern Arizona, and new information is accumulating on the behavior of several populations (see Rosen, 2002, *this report*). We also surveyed museum records for native aquatic amphibian and reptile species records (Rosen et al., 1998), and used published specimen listings (Clarkson and Rorabaugh, 1989, and therein).

During survey activities, we approached the habitat slowly, using binoculars for visual observation of frogs or surfacing salamanders and turtles, as well as for fishes. We then walked the water margin counting frogs or other animals as they moved or were otherwise observed. Finally, whenever possible we sampled each site with dipnets (6 mm mesh), seines (3 x 1 m and 8 x 1.8 m; 4-6 mm mesh), and gill nets (variable mesh sizes) to confirm species identifications and determine relative abundances for tadpoles, salamanders, turtles, and fishes. We also made nocturnal visits when diurnal surveys were deemed insufficient to document species occurrences. In some cases, netting could not effectively be carried out due to a variety of access, weather, water, or bank conditions. Thus, we did not achieve a complete survey of all abundant vertebrate species at every site.

The drought of 1994 allowed us to narrow our survey efforts to the more perennial waters. In wetter years, negative results may occur because a site has dried often and has not been re-colonized or re-stocked. Based on our interviews, almost all waters that were perennial in 1994 had retained surface water since 1989, and most had been perennial since about 1976. We are thus able to analyze samples from a time when faunal patterns were clearly shown and drought refugia for leopard frogs were readily identifiable.

Based primarily on these data, we performed a principal components analysis (Gauch, 1982; SAS Institute, 1990) on the observed aquatic vertebrate assemblages. We eliminated sites for which we believed our sampling was not complete enough to identify most of the abundant aquatic vertebrates. We ordinated the observed abundance of each species at each sampling site on a scale of 0-3 (absent, uncommon, moderately abundant, very abundant): rankings depended on common sense expectation based on trophic level, taxonomic category (Order), and field experience. For example, a rare frog would ranked low even when several were found calling at a site, whereas a snake species observed in similar numbers would be ranked high based on its higher trophic level and generally secretive nature. The resulting ordination value matrix was utilized to create a covariance matrix for principal components analysis, preserving the statistical weight of each species inherent in its frequency of occurrence and ordinated abundance.

Monitoring

We generally followed field monitoring protocols for anurans of the kinds described in Heyer et al. (1994). A variety of monitoring methods was employed as a matter of feasibility and

convenience: frogs were monitored in a variety of ways depending on personnel, time of day, visibility, time available for monitoring, and weather. Monitoring results were used here if they met the following three standards: (1) the habitat area occupied by frogs at the population site was thoroughly examined, (2) the survey was carried out by a trained observer known to be competent at surveying for ranid frogs, and (3) the survey was conducted under appropriate conditions of season and weather. Direct visual counts, splash counts, and dipnet counts of individuals were recorded and enumerated according to life history stage (eggs, small larvae, large larvae, metamorphs and juveniles, subadults or small adults, average-sized adults, and large adults). Tadpoles were excluded from the numerical result in situations where large numbers of small individuals were observed, and egg masses were also eliminated from the enumeration of observed individuals. Generally, familiarity with localities permitted ranid frog species identification; however, we threw out data judged to possibly contain uncertain species identifications.

For ponds, daytime counts were based on extended observations made visually, with binoculars if necessary, and followed if necessary by an attempt to flush frogs if they could have been overlooked. In streams, counts were based on walking along stream sections and counting all visible frogs plus splashes made by escaping frogs that were not seen. At night, a headlamp or bright hand-held flashlight was used to meticulously examine the habitat, and these results were supplemented by adding of any splashes made by unseen, escaping frogs. Most sites were monitored in unique ways adapted to conditions of accessibility and visibility, so comparison of numerical values among sites is useful only at a general level. We made many of the observations ourselves, but also collected large numbers of them from data sheets filled out by field technicians and other researchers.

Re-establishment Program

CLF tadpoles were released at 18 sites: 7 un-enclosed wetland sites at SBNWR with bullfrogs, 2 fenced exclosures at SBNWR, 2 stock ponds near SBNWR that were free of bullfrogs, 5 small schoolyard ponds in nearby Douglas, Arizona, and 1 screened-in ranarium at SBNWR (stocked twice). Releases were done in spring; sites were monitored at least once/yr, and generally 2-20 times/yr by us, Arizona Game and Fish Department herpetologists, refuge and ranch personnel, and public school students and their instructors.

In late June 1993, 789 CLF tadpoles were salvaged from a drying lobe of a pond (Rosewood Tank), and used for the first round of leopard frog releases (see below). They were divided among seven existing sites at SBNWR, six of which had existing artesian well water supplies, and one of which had a natural spring. Habitats varied from ponds to spring pools and runs. Three of the sites had Yaqui topminnow (*Poeciliopsis occidentalis sonoriensis*), one had topminnow and Yaqui chub (*Gila purpurea*), two had these plus beautiful shiner (*Cyprinella formosa*), and one had longfin dace (*Agosia chrysogaster*) and non-native mosquitofish (*Gambusia affinis*). Although bullfrog were being removed at these sites, they remained abundant at the time of leopard frog release (see Schwalbe and Rosen 1988; Rosen and Schwalbe 1995, 2002, *this report*).

The source pond is on Magoffin Ranch, 11 km east of SBNWR. In April 1994, when this pond dried completely, half the tadpoles present (n=188) kept in a pool dug in the dry floor of the tank, which was supplied with water as needed by the Magoffins, and the other half were brought to a second site, at SBNWR, that was fenced to exclude bullfrogs. Tadpoles hatched at Rosewood in 1995 were translocated to another pond (Shoat Tank) on Magoffin Ranch (see below). Partial egg masses from these three sites were used to rear tadpoles for subsequent

releases. Breeding populations established in Douglas also contributed progeny that were released at an a new pond (HQ Pond) on Magoffin Ranch. Further details are given below (see also Rosen and Schwalbe, 1998b).

The fenced site at SBNWR ("leopard frog enclosure")consists of a 1-m tall galvanized wire screen (hardware cloth, 3 mm emsh) fence enclosing an area of 0.7 ha. The fence extended 0.2 m into the ground, and eaves were added atop the fence, in July 1994m after bullfrogs climbed in. Four small pools (4 x 8 m, 1-2 m deep) had been constructed in the center of the enclosure and supplied with artesian well water. Herons were partially excluded from the ponds with 15 cm mesh predator netting. Checkered garter snakes (*Thamnophis marcianus*) were generally present in the exclosure, although they were removed when captured. Juvenile bullfrogs occasionally penetrated the exclosure and were successfully removed within 1-2 mo, until they survived and bred in the enclosure in 1999. Census counts (splash counts, binocular surveys, night counts) were taken at this site several times per year. In spring 1998, 123 more CLF tadpoles and metamorphs were released at this site.

A second, similar, fenced exclosure was completed in 1998. It contained a concrete- and rock-lined artificial stream that was stocked with topminnow and chub in summer 1998. Approximately 500 Chiricahua leopard frog tadpoles reared in Douglas were released in the enclosure in 1999, and 120 more, plus 3 large adults from a ranarium at SBNWR (see below) were released in 2000. However, adult bullfrogs penetrated the exclosure fence, which was only 0.75 m tall, and were present and breeding beginning summer 1999.

In 1995, tadpoles from the Rosewood Tank were moved to the second ranch pond (Shoat), which was supplied by a refurbished well. In fall 1996, parts of three egg masses from Shoat were transferred to Douglas High School, and these were later supplemented by small portions of egg masses produced large frogs surviving at Rosewood. In 1997, a new pond (HQ) with a well water supply was constructed at Magoffin Ranch. It was stocked with 41 tadpoles in May 1997, 73 in June 1998, and 10 were added in May 1999, all from Douglas High School (see below).

The eggs collected from Shoat in fall 1996 were reared in a classroom at Douglas High School and released in May 1997 into a small pond (3 X 4 m, 1.5 m deep) on-campus in a natural studies property. This pond was constructed by refuge and high school personnel in winter 1996-7, and a larger pond nearby (ca. 25 X 45 m, 2 m deep; 100 m away) was cleared of non-native fish and stocked with native Yaqui topminnow and Yaqui chub. Both ponds are fitted with float valves and supplied with municipal water. The frogs apparently dispersed to the larger pond, and on March 11, 1998, egg masses were observed. One adult male bullfrog occupied the pond from 1998-2000 (when it was trapped), probably having dispersed from new golf course ponds 2 km to the north.

The Douglas High School efforts resulted in a national award, with a prize that was used (spring 1998) to construct four small concrete pools for native fish (*P. occidentalis sonoriensis, Agosia chrysogaster*) and leopard frogs (*R. chiricahuensis, R. blairi*) at other public schools in Douglas. These ponds were surrounded by chain link fences and had hardware cloth barriers at ground level. They were also fitted with float valves and supplied with municipal water. Classroom-reared CLF tadpoles were divided among three of these school's ponds in May and September 1998. as follows: Marley was stocked with topminnows and 250 tadpoles, Huber with longfin dace and 500 tadpoles, and A Avenue School pond with topminnows, chubs and 250 tadpoles. In September 1998, 100 tadpoles from the classroom were also released in the large high school pond. The fourth pond received 10 *R. blairi* larvae in 1998 that were not seen

subsequently. In May 2000, 50-100 *R. chiricahuensis* larvae from the classroom were released in each of the four small concrete ponds.

The ranarium at SBNWR (a completely screened-in, 4 X 4 m X 2.5 m tall enclosure, with a 1.2 X 1.7 m pool, 1 m deep) was stocked with 10 wild-caught adult Chiricahua leopard frogs from a road puddle on Magoffin Ranch in fall 1996. These presumably came from Belency Tank on Magoffin Ranch, the only possible source of frogs of that size known in the region. These all died over the course of 14 months, and chytridiomycosis was identified from their carcasses (Bradley et al., 2002, *in press*). The Belency Tank population abruptly declined and disappeared after August 1996, with just one frog seen subsequently, a lethargic and apparently sick one in November 1996. In June 1998, 10 metamorphs reared in Tucson from a fresh Rosewood Tank egg mass were released in the ranarium. Insects can enter the ranarium, and a light to attract them was usually kept on for 1-2 hr/night in 1997 and 1998.

RESULTS AND DISCUSSION

I. Survey Results.

We investigated 175 wetland sites, of which 107 had surface water during our visits. A few perennial waters contained no perennial-water vertebrates. These were in the bedrock plunge-pool habitat type in which disease- or pollution-related die-offs of ranid frogs had previously been observed (Hale et al. 1995). All other perennial waters we surveyed contained either introduced fishes (n=34 localities), introduced tiger salamanders (n=13 localities), or bullfrogs, either alone or with other exotic species (n=31 localities); or they contained Chiricahua leopard frogs (n=19 localities). Chiricahua leopard frogs co-occurred with centrarchid fish (green sunfish, *Lepomis cyanellus*) in one case of limited overlap, and with tiger salamanders twice, and were never found co-existing with bullfrogs during this survey. There was a significant negative association between presence of bullfrogs and centrarchid fish and persistence of Chiricahua leopard frogs (Table 1).

Table 1. Association of introduced vertebrates with Chiricahua leopard frog (CLF) in southern Arizona. Tabled numbers refer only to sites where the Chiricahua leopard frog was either present during our 1993-1995 surveys ("Present", n=17 localities), or absent and presumed extirpated. "Absent" (n=25 localites) are sites where the leopard frog was formerly recorded or was suspected based on occurrence within 10 km in comparable habitat. Localities with >1 introduced species are not included here (none supported CLF). Two CLF occurrences with <4 adults and no evidence of a breeding population (1 each with sunfish and salamander), are also excluded (see text).

Non-Native Taxon	Frequency of Occurrence of Non-Native Taxon: CLF Present	CLF Absent	Binomial probability under null hypothesis of no exotic species effect
bullfrog	0 of 17	9 of 25	0.01
centrarchid fish	0 of 17	5 of 25	0.04
tiger salamander	2 of 17	5 of 25	0.50
salmonid fish	0 of 17	3 of 25	0.13

The single co-occurrence of Chiricahua leopard frogs and non-native fish (green sunfish) was seen at low water in late July 1994, in central Peck Canyon, Atascosa Mountains (the northeast part of the Pajarito complex). Three adult frogs were found in a 0.5 km perennial reach with an abundance of large (7-20 cm total length) green sunfish. This canyon system, specifically including this local site, has been surveyed for ranid frogs four times spanning 1990-1999, with no evidence of leopard frog reproduction at the sunfish site (S. Hale, E. Wallace, unpublished data). We interpret this case to represent incidental overlap involving known frog populations reproducing elsewhere in the Peck Canyon system, where introduced species were absent.

Observations of co-occurrence of the CLF and non-native tiger salamanders suggest that these species may co-exist successfully. In Tom Ketchum Tank, Pedrogosa Mountains (SW flank of the Chiricahua Mountains), two adult frogs were found with a few large (ca. 30 cm total length) paedomorphic cannibal morph salamanders. In this case, the frogs may have been emigrants from Leslie Canyon (discussed below), 7 km distant. The salamanders occupied a part of Leslie Canyon during 1996-1998 without obviously affecting the frogs, although the latter declined subsequently. However, at Garcia Tank, Altar Valley, an isolated CLF population persisted at least from 1994-2001 despite a moderate-low density of tiger salamanders. Co-existence of these two species has also been reported in New Mexico (R. Jennings, unpublished reports). In a more recent observation, a CLF population in the Baboquivari Mountains expanded dramatically in 2001, following a tiger salamander disease episode in 2000. We have not seen leopard frogs in ponds with very high densities of tiger salamanders.

II. Habitat Characteristics.

Principal components analysis of aquatic vertebrate assemblage structure (Fig. 2) illustrates the formerly broad occurrence of the CLF. It occurred in lakes and ponds (all of which are artificial in the region of study), as well as small and large springs and streams, in both montane and valley settings. PC1 is an axis separating large perennial habitats (lakes, larger streams, large perennial stock ponds) from smaller, more ephemeral or varying habitats (small streams and springs, semi-perennial and ephemeral stock ponds). The CLF has gone extinct in the larger, more perennial sites, which are, of course, now inundated by exotic species. It persists in a narrow band on the left end of this axis, along with the tiger salamander, which is highly intolerant of predatory fish (Collins et al., 1988).

PC2 is an axis tending to separate streams from ponds and lakes. CLF populations are arrayed in multivariate space in two clusters along this axis. The uppermost cluster consists of small natural lower montane streams with a diversity of native reptiles and anurans. The central region cluster represents extant CLF populations in semi-perennial stock ponds that tend to support few vertebrate species, primarily native anurans. The negative end of this axis reflects the presence of formerly semi-perennial waters on the valley floor that are now stabilized and perennial, and are occupied by bullfrogs, non-native fish, and tolerant members of the original herpetofauna such as yellow mud turtles (*Kinosternon flavescens*) and checkered garter snakes. This axis, then, illistrates the two primary remaining habitats of Chiricahua leopard frogs in southern Arizona--small montane streams and semi-perennial stock ponds.

The stock tanks, streams, and springs where the CLF now occurs are small and shallow, and many nearly dried in 1994 (Rosen et al., 1995). Continued drought in 1995 and 1997 revealed that some sites retaining water in 1994 dried subsequently, reducing but not eliminating frog populations (M. Sredl, E. Wallace, V. Miera, personal communications). Deeper and more highly oxygenated waters, including stock ponds, supported introduced species, which are absent at leopard frog localities primarily because they are less tolerant of drought or hypoxia than

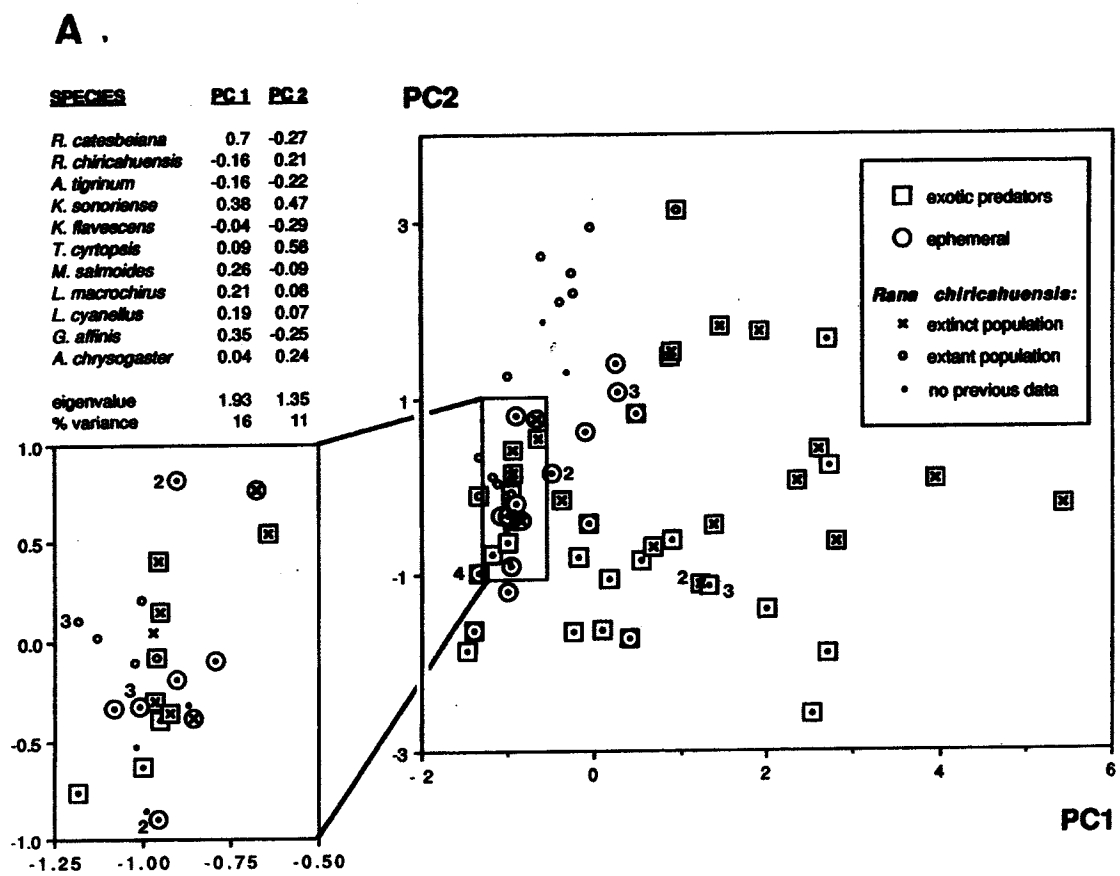

Figure 2. Principal components analysis of aquatic vertebrate assemblages at 87 localities in the range of the Chiricahua leopard frog in southern Arizona. Species whose Eigen values are listed at lop left had the highest scores on at least one of the axes. Numbers on the face of the graph indicates localities superimposed (hidden points): in each case the hidden symbols are identical to those overlying them.

A. Localities are coded (see legend) to display the relationship of Chiricahua leopard frog population status to habitat drying and presence/absence of introduced species. Enlarged portion of graph is at bottom left; eigen vectors at upper left.

B. Centroids (mean values on PC1 and PC2) for the locality points in (A) according to habitat type category.

leopard frogs. Thus, as a result of the non-native species invasion, the CLF is now confined to marginal habitat (small, shallow, unpredictable hydroperiod) in Arizona, making it vulnerable to extinction through random fluctuations, drought, disease, or other unknown causes.

III. Habitat Modification and Introduced Species Effects.

We did not find the CLF during 1993-1995 in the valley floor ciénegas, where museum records confirm its former occurrence and abundance (see also Sredl and Howland, 1995). During our surveys, these wetlands were occupied by dense populations of bullfrogs and centrarchid and ictalurid fishes. These wetlands have been simplified by channelization and drainage, drastically reduced in extent, and modified by pond excavations, dams, and levees that create lentic waters varying from deep pools to large ponds.

Natural conditions in these ciénegas (Hendrickson and Minckley, 1985) can be inferred to include seasonal swamping and drying (possibly accompanied by fire in grassland valleys) under the highly seasonal rainfall pattern of the region. The serious, mosquito-borne, malaria problems reported near ciénegas in early historical accounts make it clear that there was much temporary water unoccupied by fish, or at least with low fish density. Such a scene, with extensive shallow wetlands, a variety of mostly small pools of varying depths, few large native predatory fish, and variably-timed hdyroperiods in pools of different depth and position with the ciénega complexes, would have provided excellent conditions for leopard frogs. Marshes and streams of grassland valleys in Arizona probably supported many of the original core populations of Chiricahua leopard frogs, while the mountain stream populations (which now seem to be characteristic habitat) may have been somewhat peripheral, though certainly significant as drought refugia. Like the occupied ciénegas, they are headwaters streams, and the Chiricahua leopard frog is characteristically a headwaters specialist. The longer duration, more fish-resistant larva of a frog like the bullfrog may have offered minimal advantages under seasonal desiccation in the ciénegas.

The hypothesis that the CLF could persist with or replace the bullfrog under restored natural conditions in the ciénegas remains to be rigorously examined and tested. However, such co-existence has been observed during 1998-2001 at the least-modified site, the Empire Ciénega and associated Ciénega Creek (D. Caldwell, personal communications; personal observations by PCR), with bullfrogs breeding in stock ponds and the deepest portions of Ciénega Creek, and leopard frogs breeding in a smaller, laterally-isolated semi-perennial stream segment. This is especially interesting, as there do not appear to be any other sources of leopard frogs in the area: the small population may be maintaining itself. Bullfrogs seem to have arrived in the area sometime at or around 1986 (Rosen and Schwalbe, 1988), and are apparently proliferating slowly or poorly.

Similarly, in 2000, Eric Wallace discovered a few adult *R. chiricahuensis*, with evidence of rare larval survival in the lowermost pools of O'Donnell Creek, a natural ciénega-stream in the Canelo Hills, not far south of the Ciénega Creek drainage basin. Although O'Donnell Creek is severely infested with non-native green sunfish and crayfish (*Orconectes virilis*), the lower pools dry periodically and may therefore offer some amelioration of predation pressure. In this case, however, it appears that this frog population may persist as a result of immigration from semi-perennial springs and rock tanks within a 3 km radius (E. Wallace, pers. comm., 2000). Bullfrogs appeared to be in process of invading this area during 2000-2001, using pre-exisitng stock ponds (Finley Tank, Post Canyon Tank) to bridge the gaps between Babocomari Ciénega, which was only invaded by bullfrogs after 1988 or 1989) and O'Donnell Ciénega. Both this situation and the

one at Ciénega Creek appear to be a dynamic, and we do not know how the interactions among native and exotic species will be resolved.

In other valley ciénegas, habitat modification is more extensive, and there are generally dam ponds or dug ponds with large bullfrog populations. Dams lessen the scouring effect of flash floods, which are a natural part of the Southwestern hydric regime. They thus protect non-native fishes, which are more susceptible to flood mortality than natives (see Minckley and Meffe, 1987). Flash-flooding may also permit persistence of the lowland leopard frog in desert streams despite the introduction of bullfrogs (Sartorius and Rosen, 2000), because leopard frog tadpoles commonly metamorphose before summer flooding or drying takes place. Dams also reduce the chance of habitat drying, creating refugia for large, non-native predators. They create a habitat type that is regionally alien, in which introduced species from eastern North America have strong competitive and predatory advantage. We consistently observed abundant and diverse non-indigenous species in modified, lentic habitat types.

In 1994, Chiricahua leopard frogs were not found in the major montane stream systems (defined here as those that support native fish populations) in southern Arizona, with three exceptions. Most mountain stream canyons where the frogs disappeared have dams supporting a diversity and abundance of introduced species, primarily predatory fishes. Museum records demonstrate that Chiricahua leopard frogs formerly occurred in all of these systems, including in modified habitat. Rosen et al. (1995) showed that a time-line for fish introductions in the Chiricahua Mountains corresponds to recent declines of the CLF.

Bear Canyon in the Huachuca Mountains is the only system with native fish (Minckley, 1973) that we did not survey. It originally had leopard frogs (Gilbert, 1973), but now contains non-native crayfish (*Orconectes virilis*), and leopard frogs appear to be absent (P. Holm, E. Wallace, personal communications). We are not aware of any dams or other significant habitat modifications in Bear Canyon.

The three cases where the CLF remains in major mountain canyons are Sycamore Canyon in the Pajarito Mountains, Gardener Canyon in the Santa Ritas, and Leslie Canyon NWR in the Swisshelm Mountains, adjoining the Chiricahuas. All are largely natural systems without substantial habitat modifications. They are not currently (2001)known to support non-native fishes, bullfrogs, or crayfish. At Sycamore Canyon, bullfrogs invading from artificial lakes or stock ponds have been seen in the mid-1990's (when they were removed by various persons) and again in spring 2001, when numbers of juveniles appeared in the stream (E. Enderson, R. Bezy, personal communication, 2001), but we have no evidence that they have persisted or bred there. During 1994-2000, 3 or more semi-perennial stock ponds in the upper basin of Sycamore Canyon were found to support variably substantial populations of CLF, and may have been contributing to the stream population, which is normally quite small and has shown low to moderate tadpole abundances. As at Ciénega Creek and the Canelo Hills, it is critical that we monitor this situation to track the course and dynamic (or lack thereof) of bullfrog invasion in natural CLF habitat.

Gardener Canyon and Leslie Canyon have apparently not yet been invaded by bullfrogs or non-native fishes, or if they have, they were removed before they became established or came to our attention. Gardener Canyon has little pool environment that looks suitable for bullfrogs or green sunfish, the two most likely invaders. Leslie Canyon may also be relatively cool and shady for these exotics, although green sunfish were introduced in 1995 and removed by two of us (C. Cobble, M. Magoffin) before they began to establish themselves. It seems possible that the reason exotic fish are absent is that lack of obvious dams and ponds (i.e., "attractive nuisances") has minimized their attractiveness as fish-release sites. Further documenting a synergism between habitat

modificationand introduced species impacts, and understanding its mechanism and whether it offers hope for mitigating the non-native species onslaught, remain key challenges for conservation in this region and elsewhere in the American West (see Moyle 1973; Hayes and Jennings 1986, 1988; M. Jennings and Hayes 1994; Fisher and Shaffer 1996; Adams 1999). We will need strong evidence on this question, since restoration of natural habitat conditions may be both contentious and costly.

IV. Experimental Re-establishments.

Introductions of Chiricahua leopard frogs into sites with bullfrog populations failed. No leopard frogs were ever observed at the seven 1993 release sites at SBNWR, nor elsewhere at SBNWR, although many thousands of other frogs were observed and captured. Similarly, at the stream enclosure, which was occupied by bullfrogs, leopard frog larvae failed to thrive, and no recruitment occurred. Dipnetting in July 2001 yielded three CLF larvae that were not robust and appeared to be emaciated. The three large adults reared in the ranarium were still occupying the largest stream pool at this site in August 2001, and may still remain. Failure of CLF larvae in the stream enclosure is consistent with competitive mechanisms of bullfrog impact on native ranids (Kupferberg, 1997; Kiesecker and Blaustein, 1997, 1998).

The leopard frog enclosure CLF population survived to 1999. Eggs masses were observed in September-October of each year 1994-7, indicating that eggs produced in 1993 at Rosewood Tank produced metamorphs in May-June 1994 and successfully reproducing adults at an age of approximately 1 yr. The population peaked in summer 1996; in late summer many frogs appeared to be underweight; dead and lethargic frogs were seen in fall-winter 1996-7, probably suffering from chytridiomycosis (Bradley et al., 2002, *in press*), although carcasses fresh enough for histology were not found. The population persisted at lowered abundance in 1997-1999 (Fig. 3). In 1999, bullfrogs bred in the exclosure, and when the site was dried at the end of 1999 only a single adult leopard frog was recovered.

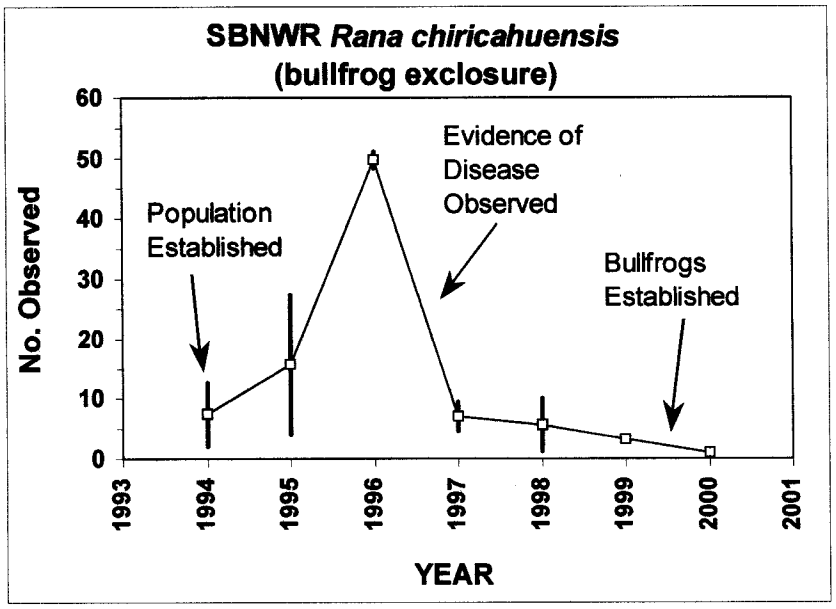

Figure 3. Counts of observed Chiricahua leopard frogs in a bullfrog exclosure at San Bernardino NWR, Arizona. Annual means and 95% confidence intervals are shown, along with key events in the history of the population.

Table 2. Summary of monitored natural and re-established populations of the Chiricahua leopard frog (*Rana chiricahuensis*) in southeastern Cochise County, Arizona, 1993-2001. Details are provided in text. Population status is as of September 2001.

Population Site	Non-native Species Present	Date of Population Origination	No. in Original Release	Minimum Persistence Time (yr)	Presumed cause of failure (unless extant)
7 SBNWR Wetland Sites	bullfrogs	1993	788	0	bullfrog predation
SBNWR Stream Enclosure	bullfrogs	1999-2000	620	0	bullfrog predation or competition
SBNWR Exclosure		1994	188	5	bullfrog invasion, chytridiomycosis (terminated)
Shoat Tank		1995	66	2	well failure (desiccation)
Magoffin HQ Tank		1997-8	114	3	(population extant)
Douglas H.S. Pond (small)		1997	27	4	(population extant)
Douglas H.S. Pond (large)		1998	none *	3	(population extant)
Marley School		1998	250	1	unknown**
Huber School		1998	500	2	desiccation (water supply turned off) **
A Avenue School		1998	250	2	unknown **
Faras School		2000	unknown	1	(population extant)
SBNWR Ranarium		1996	10	1	chytridiomycosis
SBNWR Ranarium		1998	10	3	desiccation (water supply turned off)
Belency Tank		pre-1993	none ***	≥ 4	chytridiomycosis
Rosewood Tank		pre-1993	none ***	> 9	(population extant)
Leslie Canyon		pre-1993	none ***	> 9	(population extant)

* immigration from small Douglas H.S. pond

** presumed failure not fully confirmed; additional releases have maintained or re-established populations

*** naturally occurring population monitored beginning 1993; Rosewood Tank managed starting in 1994

Table 3. Summary of monitored natural and re-established populations of the Chiricahua leopard frog (*Rana chiricahuensis*) in southeastern Cochise County, Arizona, 1993-2001, showing fish species at sites and summary statistics. Fish species are *Agosia chrysogaster* (AC), *Cyrpinella formosa* (CF), *Gambusia affinis* (GA), *Gila purpurea* (GP), and *Poeciliopsis occidentalis* (PO).

Population Site	Fish Species Present	Minimum Persistence Time (yr)	Presumed cause of failure (unless extant)
Huber School	AC	2	desiccation (water supply turned off) **
Black Draw Spring	AC, GA	0	bullfrog predation
Leslie Canyon	GP, AC	9	(population extant)
Belency Tank	GP	4	chytridiomycosis
A Avenue School	PO, AC	2	unknown **
Twin Pond	PO, GP, CF	0	bullfrog predation
Double PhD	PO, GP, CF	0	bullfrog predation
North Pond	PO, GP	0	bullfrog predation
Douglas H.S. Pond (large)	PO, GP	3	(population extant)
SBNWR Stream Enclosure	PO, GP	0	bullfrog predation or competition
Tule Pond	PO	0	bullfrog predation
Robertson Cienega	PO	0	bullfrog predation
Bunting Spring	PO	0	bullfrog predation
Magoffin HQ Tank	PO	3	(population extant)
Faras School	PO	1	(population extant)
SBNWR Exclosure	none	5	bullfrog invasion, chytridiomycosis (terminated)
Shoat Tank	none	2	well failure (desiccation)
Douglas H.S. Pond (small)	none	4	(population extant)
Marley School	none	1	unknown**
SBNWR Ranarium	none	1	chytridiomycosis
SBNWR Ranarium	none	3	desiccation (water supply turned off)
Rosewood Tank	none	9	(population extant)

* immigration from small Douglas H.S. pond

** presumed failure not fully confirmed; additional releases have maintained or re-established populations

*** naturally occurring population monitored beginning 1993; Rosewood Tank managed starting in 1994

Categorical Summary:

Persistence times:	mean (yr)	S.E.	n
With Bullfrogs	1.50	0.793	8
With Gila Chubs	2.29	1.286	7
With Gila Topminnows	0.82	0.377	11
With Longfin Dace	3.25	1.974	4
Alone	3.57	1.066	7
Re-establishment Sites Only	1.42	1.066	7
Re-est. Sites without Bullfrogs	2.45	0.390	11
Without Bullfrogs	3.50	0.701	14
Overall	2.23	0.573	22

Leopard frogs were introduced into nine other sites that lacked populations of introduced species (Table 2). They persisted for at least a year in all of these, and were still present in 2001 as a result of initial re-establishment introductions at five of the sites as well as at Rosewood Tank, which was also intensively managed during the drought of 1994-1999. At the three small concrete ponds at schools in Douglas, they may have disappeared during 1999 or early 2000, but tadpoles released in them in May 2000 were apparently represented as adults that were seen in summer 2001. There are currently at least ten existing populations in the study region, including the sole known natural population, persisting at Leslie Canyon. In this sense, the re-establishment program appears successful (see also Denton et al., 1997), although the species remains highly threatened in this region.

The re-establishment sites varied in degree of enclosure and in aquatic community composition. They persisted with various combinations of native fishes (Table 3), although Yaqui and Gila chubs (*Gila purpurea, G. intermedia*) ate CLF larvae voraciously in laboratory aquaria (P. Rosen, unpublished), and undoubtedly have an effect in natural environments. Chiricahua leopard frogs persisted at sites with herons, checkered garter snakes, and various small mammalian predators, including domestic cats (*Felis catus*) in Douglas and raccoon (*Procyon lotor*) at SBNWR. They also persisted at nearby Leslie Canyon NWR in a perennial stream, where coatis (*Nasua nasua*) and other small predators were abundant, and non-native tiger salamanders (*Ambystoma tigrinum mavortium*) appeared in 1995, reproduced in 1996-7 in semi-perennial fish-free pools, and apparently disappeared during drought in 1998-9.

Possible causes of observed population failures are listed in Table 3 and discussed in more detail by Rosen (2002, *this report*). Post-metamorphic death syndrome (Scott, 1993) was observed at several sites, and was associated with chytridiomycosis (Bradley et al., 2002, *in press*), seriously complicating recovery efforts here and elsewhere for the Chiricahua leopard frog. Desiccation was the other evident cause for population failure. A natural event was observed in 1994 when the Guadalupe Canyon (Peloncillo Mountains) CLF population disappeared, as the last water hole in the exotics-free region of the canyon dried completely. At Shoat Tank, problems with the well led to a decline in water levels and eutrophic conditions, leading to a partial frog die-off in 1996. This situation was fixed and the few surviving frogs appeared healthy, until the well failed again in 1998 and the site was abandoned. At Huber School and at the Douglas H.S. small pond, we found very low water levels in January 2000, after someone closed the supply valve, and we understand this was repeated at Huber School and that population perished. There were rumors, certainly plausible if not true, that the valves were closed by someone from Douglas as some sort of response to Endangered Species Act or AGFD management concerns. The eventuality that wells will require timely, possibly expensive maintenance, and the evident reality that any artificial water supply is a potentially fickle lifeline for an aquatic frog, should be noted.

RECOMMENDATIONS

1. Programs like the one involving the Douglas Public School system, Malpai Borderlands Group ranchers, and various conservation agencies should be facilitated by publishing guidelines demonstrating willingness to permit possession of threatened or other sensitive native anurans and fishes.

2. Agency guidelines should be developed explicitly stating the terms and requirements that apply to individuals or organizations involved with propagating native or threatened anurans and fish. These guidelines may be drawn up "from scratch" to make sure they are as reasonable as possible; and if that is in contradiction to laws or rules, the agencies should actively pursue alterations that allow the necessary flexibility.

3. A listing of funding sources for non-agency groups involved in conservation should be ready for distribution when appropriate.

4. Active conservation measures for leopard frogs appear successful at Ramsey Canyon as well as in the report area. Agencies should streamline the process and get them going in many places.

5. The ranarium at San Bernardino NWR should be reactivated.

6. The leopard frog enclosure at San Bernardino NWR should be reactivated once the fence improvements needed to more fully exclude bullfrogs are identified.

7. Similarly, the fence at North Fork stream at San Bernardino NWR should be redone.

8. Provision should be made to continue essential monitoring and record-keeping at existing active management sites in Douglas, San Bernardino Valley, and elsewhere in Arizona..

9. Leopard frogs, bullfrogs, fishes, and other aquatic species should be closely monitored (at least 1-2 times per year, preferably more) at Sycamore Canyon (Pajarito Mountains), Ciénega Creek (Empire Ranch), and O'Donnell-Post Turkey Creek Canyons (Audubon Research Ranch, Canelo Ranger Station, Canelo Hills Nature Conservancy Preserve) starting immediately and continuing for 2 or more years as necessary to understand the processes and amount of progress in ongoing bullfrog invasions.

10. Active research should be encouraged to explore the relationship between habitat type, habitat modification, and the persistence of native ranid frogs in the face of multiple threats. An objective of this work should be to identify environmental characteristics that allow native ranids to persist and thrive despite these threats.

11. The Douglas Public School System, Malpai Borderlands Group, and San Bernardino NWR should jointly receive recognition for preventing and forestalling the extinction of the Chiricahua leopard frog in the area of Douglas and the San Bernardino Valley.

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INTRODUCTION AND RECOMMENDATIONS for

CONCEPTUAL DRAFT CONSERVATION PLAN FOR THE CHIRICAHUA LEOPARD FROG IN THE SAN BERNARDINO VALLEY REGION

Presented as Deliverable to AGFD Heritage Grants Program, IIPAM Project I99016

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Prepared: 11 June 1999
Submitted with report: 1 Jan. 2002

INTRODUCTION

The attached plan was submitted to the Malpai Borderlands Group (MBG)following lengthy review by AGFD and USFWS, as shown in the accompanying letter of transmittal. This plan was used as the basis for a "Candidate Conservation Agreement with Assurances / Safe Harbor Agreement (CCAA/SHA) prepared for the Malpai Borderlands Group by Mr. Bill Lehmann, and subjected to agency and legal review. It should be noted that the attached plan was neither written nor intended to be a Safe Harbor Agreement. The expected timing of listing of the Chiricahua leopard frog as Threatened under the Endangered Species Act (ESA) conflicted with the CCAA approach, which requires that a species not be listed. Thus, the CCAA/SHA required reworking. I have not been informed if such re-working has been carried out, but SHA negotiations exist and may or may not be at some stage of agreement. The process is quite slow, glacial compared to the pace of change in frog populations.

Therefore, I cannot say now how or if the attached document will ultimately be deployed. The terms of Safe Harbor Agreements usually appear to be unfavorable for the Chiricahua leopard frog, although not in th Malpai case. Providing an SHA to a housing or other real estate developer or potential developer may function primarily as a hold-harmless agreement to permit eventual destruction of the frogs, their habitat, and potential habitat, without penalty. Under the "return to baseline" terms of an SHA, any frogs in excess of those initially known to be present (the "baseline" value) can be eliminated by the property holder. This offers protections against perceived capriciousness and unpredictable outcomes under the ESA, and as such is a response to a dubious situation. Until the ESA can be corrected, though, SHA may be reasonable.

In the case of ranchers, Safe Harbor Agreements may be a reasonable approach to leopard frog conservation. Many ranchers have clearly demonstrated genuine interest in conservation in general and, in some cases, frog conservation in particular. Secondly, some ranchers have made it clear that they are attempting to institutionalize the highest priority issue in Arizona concerning open lands, by selling conservation easements prohibiting subdivision and housing developments. These two conditions, (1) demonstration of genuine interest in frog conservation, and (2) unequivocal commitment to open space as against subdivision and development, seem to me to be necessary and sufficient conditions for conservationists to support SHA's for ranchers who want to work with native ranid frogs. The MBG appears to meet these conditions, and the Magoffin Ranch

in particular clearly does. It is responsible conservation biology to provide whatever proper benefits the law allows for such exemplary work by private citizens, even if the law is flawed and needs to be fixed.

It must be recognized that although cattle ranching *per se* can form a natural collaboration and alliance with frog conservation, many cattle ranches are actually real estate holding companies with little or no real commitment to maintaining open space or natural biodiversity. Close to urban or suburban developing areas, the land value of cattle ranches is one or more orders of magnitude greater than the value of the actual ranch operation, which generally employs a handful of vaqueros and a managing/owning family. An SHA in this situation, without an easement protecting open space, is merely a license to subdivide without consulting the U.S. Fish & Wildlife Service. Many areas would currently have a surveyed "zero baseline" condition as result of the infestations of harmful non-native species behind dams of various kinds, but the known dispersal ability of ranid frogs implies that dispersal is ongoing, thus take is ongoing, and re-colonization is reasonably predictable assuming that the harmful non-native species or environmental conditions favorable to them are removed. It should be realized that a Safe Harbor Agreement is a compromise and a gamble from the standpoint of conservation biology. Even in the best case under an SHA, the landowner may get a significant windfall, without risk, if the ranch's long-term appraisal soars because it hosts outstanding biodiversity. It would seem to be a rare circumstance that would find a real estate developer a good gamble under SHA.

Ranchers may desire Safe Harbor Agreements as a result of fears that Endangered Species Act strictures may be imposed as a result of failure of conservation plans due to uncontrollable and unpredicted factors. In that scenario, a rancher would be stuck with, let us say, leopard frogs, in declining or low numbers, or of a species reclassified from Threatened to Endangered, with a consequent abrogation of special rule protections, which apply only for Threatened species. An SHA protects against that while functionally writing off habitat, in a legal sense, in perpetuity. A possible solution may be to offer SHA under terms that require consultation on maintenance of overall habitat quality by the cooperator, so that biological problems extrinsic to their responsibilities and actions don't unfairly affect the cooperator.

A neglected area of conservation biology is, in fact, working with developers and urban managers to devise integrated ecological restoration, natural biodiversity creation under the urban-suburban regime, and development rules and regulations that prevent the most noxious consequences of urban and suburban sprawl – the spread of modified habitat and the accompanying penetration and proliferation of harmful non-native species. Until we really have that program in place, use of SHA in circumstances where real estate development is a possibility seems unwarranted. Revisions to conservation law or, alternatively, cobbled-together programs that address specific local needs, may be preferable.

RECOMMENDATIONS

- A Safe Harbor Agreement for leopard frog conservation should be finalized with the Malpai Borderlands Group, and/or Magoffin Ranch, if they so desire, at the earliest possible time, and implementation of the attached biological plan, modified as necessary, should begin as soon as all parties feel secure enough to proceed.

- Other ranching associations or appropriate private-sector groups should be encouraged to pursue, develop, and implement similar plans, and steps should be taken to provide them with the security they believe they need.

- The potential for Safe Harbor Agreements for leopard frog conservation may be evaluated with reference to the following necessary and sufficient conditions:

    - 1. There is clear and demonstrated commitment from participants to the conservation and a well-thought out plan or approach to the physical tasks necessary.

    - 2. The Safe Harbor Agreement will not facilitate eventual subdivision of open space and elimination of restoration potential for the frogs.

- Attention should be paid to assisting and promoting the development of urban and suburban development designs that avoid the currently inescapable consequences in habitat modification and non-native species spread and proliferation.

HERPETOLOGY

11 June 1999

Mr. Bill Miller, President
Malpai Borderlands Group
6226 Geronimo Trail Road
P.O. Drawer 3536
Douglas, AZ 85608

Dear Sir:

I have enclosed a draft proposal for a Chiricahua leopard frog conservation plan in the Malpai Borderlands Group area. Federally Threatened status is imminent for this species. I would like advice, comments, and recommendations from MBG and interested individuals.

This is a concept plan. It does not list specifics (such as whose ranch, which pond or tank, and how much funding is needed). Everyone should agree on the concepts before private parties commit to specific plan actions.

U.S. Fish & Wildlife Service funded my work on this. They also required much more time-consuming review by various agencies before getting it to you than I expected or desired. The benefit of this delay, though, is that apparently the agencies do not find anything overly objectionable in the concept plan you now have.

This is not a final document. MBG's response is the most important part of the process.

The people that I think are currently most interested in seeing the document or discussing the issue this are you, the Glenns, Magoffins, McDonalds, Hadleys, Scholes, Austins, and Woodlings, as well as the MBG steering committee or officers. Please share it as widely as you can.

I hope we can now move ahead with finalizing the concept and developing specific plans.

Yours,

Philip C. Rosen

CONCEPTUAL DRAFT CONSERVATION PLAN FOR THE CHIRICAHUA LEOPARD FROG IN THE SAN BERNARDINO VALLEY REGION.

Philip C. Rosen
Department of Ecology and Evolutionary Biology
University of Arizona
Tucson, AZ 85721

11 June 1999

Summary.

This is a conceptual plan for private-public conservation of the Chiricahua leopard frog (*Rana chiricahuensis*), a species proposed for listing as threatened under the Endangered Species Act. The plan is based on cooperative ventures between private ranchers and public agency conservationists. It may serve as a model for frog conservation in ponds elsewhere in the West.

The objective is to develop a plan that is agreed upon by U.S. Fish & Wildlife Service (USFWS), Arizona Game & Fish Department (AGFD), New Mexico Department of Game & Fish (NMDGF), USDA Forest Service, other agencies that may be involved, and participating ranchers and ranching organizations.

The plan will focus on voluntary public-private cooperation. The present document presents concepts that should be agreed upon by all participants before specific locations, commitments, plans, and schedules are set down as formal agreements.

The first specific plan to be developed involves private individuals associated with the Malpai Borderlands Group (MBG) in San Bernardino Valley and the Peloncillo Mountains, Cochise County, Arizona and Hidalgo County, New Mexico, in cooperation with University of Arizona, San Bernardino National Wildlife Refuge (SBNWR), and with USFWS Ecological Services, AGFD, and NMDGF wildlife biologists and managers.

Chiricahua leopard frog population numbers have declined markedly since the early 1980's. It has been eliminated from large areas by introduced species and habitat destruction, and appears to be affected by disease or pollution in ways that are not well understood. It is now most widespread and abundant in man-made ponds and tanks on cattle ranches, and may be unable to survive without them.

The relationship between public and private partners in this frog conservation plan is embodied in the following 5 points:

(1) participating ranchers and conservationists will agree, on a voluntary basis, on management that is compatible with both ranching and with frog conservation,

(2) within the agreement framework, normal ranch operations may continue and may be exempted from "take" provisions of the Endangered Species Act (based on a Special Rule, section 4(d) of the Endangered Species Act, or on other mechanisms),

(3) it is anticipated that funding for frog conservation activities will be available from various sources; ranchers will not be required to cover conservation expenses of the frog conservation work from their private funds,

(4) ranchers can materially contribute to the conservation work with their landscape knowledge, practical expertise, observations and monitoring, and

(5) improvements made to waters under the frog conservation plan may be designed to dovetail with needs of responsible livestock grazing operations.

The key landscape and ecological concepts in the frog conservation plan are embodied in the following 5 points (a-e):

(a) ranch water developments will be utilized as frog habitat, including stock ponds, steel and concrete tanks, and drinkers and wells,

(b) new populations will be established by translocation (moving) of excess or head-started (captive-reared) tadpoles or juvenile frogs from existing sites,

(c) within a plan, populations will be organized as a "metapopulation" in which different local sites can exchange individuals and genes, either naturally or by artificial interchange,

(d) individual populations within the metapopulation can be treated as core (primary) or peripheral (secondary) sites, and populations may be designated as "essential natural populations", "experimental managed populations", or "established managed populations",

(e) monitoring will focus on the success of the metapopulation and the environmental factors affecting it.

This document also points out some hypothetical pitfalls and abuses of frog conservation plans and how they might be avoided. It provides guidelines that both public and private participants should agree to in principle and in good faith. These should serve to protect both groups against real or perceived threats that are currently often expected in the relationship between government conservationists and private ranchers.

Introduction.

This document is a general, conceptual plan for frog conservation that could be modified for application in a variety of areas where cooperators can be found. It is intended to promote public-private cooperation as a primary mode of conservation for the Chiricahua leopard frog, *Rana chiricahuensis*. Ranch ponds and tanks are currently a primary habitat type for surviving populations of this species.

Public-private partnerships with minimal costs to ranchers would be the best way to conserve leopard frog populations in Arizona. Partnership agreements can provide both parties benefits by clearly stating agreed-upon expectations, and defining legal expectations with regard to declining species. They may provide benefits to ranchers through provision of quality water facilities usable both by frogs and livestock.

Once there is agreement on general concepts, a specific overall plan, and specific agreements within its context, will be developed with Malpai Borderlands Group (MBG) members. Assuming funding is available for this continuing effort, the specific agreements will be guided through the University of Arizona, as this conceptual plan has been. The master plan will be a refined version of this conceptual plan. The specific agreements will be presented in the form of work proposals that parties formally agree to carry out if and when funding is available. These proposals will specify ranches, localities, populations, locality plans, and time schedules for work on ranches, forests, and refuges.

The major goal of this conceptual planning document is to provide sound management guidelines for leopard frog recovery, and to develop a prototype for agreement between public and private partners, with reasonable guarantees to private cooperators that they will not be assuming costs of species recovery that should properly be born by publicly-funded agencies.

To function effectively, this and other conservation plans should be acceptable to private persons, advising biologists, and responsible and involved agencies. In the Malpai Borderlands region, the most important land-holding or directly-participating agencies are U.S. Fish & Wildlife Service, Arizona Game and Fish Department, New Mexico Department of Game and Fish, USDA Forest Service, and Arizona State Lands Department.

The objective of the conservation plan is to provide for the short- to medium-term (20-50 yr) survival of the Chiricahua leopard frog, and to establish and maintain one or more sets of populations that are viable in the long term (i.e., statistical survival expectation for 100 years, with a reasonable expectation for maintenance

in perpetuity). The basis of the management will be sets of local populations that will supplement and sustain each other by migrational interchange. These are termed "metapopulations".

Specific plans will include reasonable measures to minimize losses ("take") of Chiricahua leopard frogs under agreed-upon provisions, and will certainly ensure that incidental take will not threaten the metapopulation as a whole.

I am a University of Arizona biologist and doctoral student working on basic research and conservation studies concerning reptiles and amphibians. At a meeting in 1997 in Douglas, Arizona, a group of biologists, natural resources managers, and private ranchers selected the author to draft this conservation plan. Part of my role is to be a relatively impartial participant.

Financial support for development of this plan has been provided by USFWS Refuges through Kevin Cobble, SBNWR Refuge Manager. This draft plan has also been developed with input from Refuge Manager Cobble, Dr. Cecil Schwalbe (University of Arizona, USGS, Cooperative Park Studies Unit), Matt Magoffin (Magoffin Ranch, Cochise County, Arizona), Jim Rorabaugh (USFWS Ecological Services Office, Phoenix), and Mike Sredl (AGFD Ranid Frog Program).

I. Frog Conservation and Ranching, Background.

Expectation of Listing as Threatened. It appears likely that the Chiricahua leopard frog will be listed as threatened under the Endangered Species Act. There is strong support within the conservation community, Department of Interior, and state game and fish agencies for such a "listing package", especially one that recognizes that cattle ranches provide much of the habitat now utilized by this frog.

Under the "Threatened" category, the listing package may, and in this case likely would, include a "Special Rule" (section 4(d) of the Endangered Species Act) to minimize conflict with ranchers. As such, the special rule would facilitate ranching activities, particularly for participants in a conservation plan for the Chiricahua leopard frog.

To be precise, the special rule for the Chiricahua leopard frog listing will likely exempt ranchers from "Section 9" violations, if they are participants in an approved conservation plan, like the one described here. Section 9 (or "take") violations include intentional, accidental, or incidental killing of listed species. As the most pertinent example for our purposes, take would occur if frogs were killed in cleaning out a tank to keep it from filling with sediment. Incidental take could be permitted under an agreement in which parties agreed that reasonable measures were used to minimize take, and where the take did not jeopardize the frog metapopulation of the agreement area.

A special rule may also offer a Section 9 exemption for livestock operations and maintenance activities on private lands, even without a conservation plan. The rancher would still gain from plan participation if he or she were also utilizing state or federal lands, as well as by using the plan as the basis for communication and planning.

Normal ranching operations such as cleaning sediment from ponds are necessary to sustain frogs, since stock ponds tend to fill with sediment. Other kinds of ranching effects on frogs would be agreed upon, on a site-specific basis in the conservation plan for specific sites of concern. All participants would have direct input into development and implementation of the plan.

Federal listing does not end or preclude state participation in, and authority over, species management. Arizona Game and Fish Department will remain involved in frog conservation planning, and could integrate its Conservation and Management Zone concept into the plan. This would avoid delays over details, and facilitate implementation of an agreed-upon plan by those directly participating in it.

At some point after the expected federal listing, there will be a Recovery Plan devised for Chiricahua leopard frog. I would expect that conservation plans would be incorporated into the Recovery Plan, and could form the basic structure of it. The Recovery Plan has not, to my knowledge, been initiated, nor can it formally be until listing is finalized. There is no way to know now with any certainty what it would specify.

Causes for Decline of the Chiricahua Leopard Frog. The Chiricahua leopard frog in Arizona is now most widespread and abundant in man-made cattle ranch ponds and tanks. It would apparently be facing immediate extirpation in the state without these artificially-maintained habitats.

This species has been extirpated from most of its original natural aquatic habitats by introduced species (bullfrogs, catfish, bass, sunfish, crayfish), and by digging, damming, and draining of original habitat in streams and ciénegas. The dams create habitat for introduced species, which then eliminate native species of fishes and frogs. The Chiricahua leopard frog has probably also been impacted by disease and pollution, and fragmentation of metapopulations; these causes of decline are still being investigated.

Since cattle ranching has benefitted this species, there should not be unresolvable conflict between ranching and conservation in this case--possibly no significant conflict. Claims that ranching has systematically or significantly harmed leopard frogs in Arizona are totally unsubstantiated. Control of introduced species in stock ponds and tanks is tractable, whereas in natural waters it has proven extremely difficult.

In the area of our initial planning attempt, the Chiricahua Mountains, San Bernardino Valley, Peloncillo Mountains, Animas Valley, and Animas Mountains, 4 or 5 known, reproducing Chiricahua leopard frog populations are on federal land (2 or 3 Forest Service, 2 USFWS), 1 is on state land on a private ranch, and 6 are on private land on cattle ranches. Of these populations, 2 are in natural spring or stream habitat, 1 is in a leopard frog preserve enclosure, and 9 are in cattle tanks. I assume that there some few additional populations on private land that has not been surveyed for frogs. It is clear that in this region, stock waters will be very important for survival of the Chiricahua leopard frog.

II. Human Factors in Development of a Conservation Plan.

Harmonizing Conservation and Economics. It is established practice in conservation biology that locally resident people in conservation areas should benefit from conservation activity, and that economic and conservation activities should be harmonized, whenever possible. This ought to apply for the United States, as well as in Africa or other exotic locales.

Among major current economic uses of landscapes, cattle ranching in the American West is the most compatible with conservation: housing development, mining, farming, and logging under existing practices have been and remain more damaging and threatening to open space landscapes, natural biomes, and native species. Public-private conservation partnerships involving cattle ranches should be workable in many cases. Frog conservation in the Southwest is an excellent example of one such case.

Funding for Frog Conservation Activity. One major objective of this conceptual plan is to remove perceived obstacles to public-private cooperation for frog conservation. Ranchers often fear economic damage from biodiversity conservation projects involving their grazing land. Frog conservation on private lands, in particular, should not become a burden for cooperating landholders engaging in conservation-compatible activities.

We are in an excellent position in the Malpai Borderlands region to set a precedent. Chiricahua leopard frog conservation here should entail minimal costs to ranchers, and a basis of ongoing communication and cooperative frog conservation efforts already exists. We may be able to lay the groundwork of trust and procedure that can work in other regions or for more challenging species.

Certain activities, such as frog propagation and habitat management, will require funding. Plans can be agreed upon and formalized, but cannot be applied until funding can be secured. No party to an agreement is likely to accept stipulations and schedules that depend on funding that is not in hand. Therefore, the best way to protect all parties from unreasonable planning and unfunded mandates is to develop each specific plan as a proposal for funding with signatories that agree to perform the proposed work when funding is secured. Participating private or public partners will be permitted to use the proposals to solicit funds so that the process can move forward.

It is important that both public and private partners recognize plan costs and benefits. Ranchers may benefit directly from water improvements in many cases, but may be unaffected in others. In contrast, various activities involved in frog conservation could involve the ranchers' time and energy. In the best-case

scenario, ranchers might participate actively. However, the conservation plan will not demand uncompensated time and energy from private persons. Volunteerism is desirable, and can be utilized as in-kind contribution to enhance proposals for funding.

We anticipate that funding support for frog conservation activity will come from public agency programs, private foundations and environmental groups, and contributions by participants. Obtaining funding for projects will be the responsibility of project participants or project managers they designate. When funding does become available, agreed upon actions will commence and not be delayed unnecessarily.

Federal listing of the Chiricahua leopard frog is likely to enhance funding availability for its conservation. Funding sources that might support leopard frog conservation include:

Partners for Fish and Wildlife program (USFWS)
Heritage Stewardship Program (AGFD)
Arizona Water Protection Fund (State of Arizona Dept. of Water Resources)
WHIP program (Natural Resources Conservation Service)
USDA Forest Service
Heritage Grants Program (AGFD)
USFWS Refuges
North American Wetlands Conservation Act funds (USFWS)
The National Fish & Wildlife Foundation
environmental groups (e.g., The Nature Conservancy)
ranchers' organizations (e.g., Malpai Borderlands Group)

The successful cooperation of the Magoffin Ranch and the parties involved in developing this frog conservation plan (University of Arizona biologists, SBNWR, AGFD, and USFWS Ecological Services Office (Phoenix) already shows that ranching can benefit from successful frog conservation efforts. Wells were drilled and other modifications made to ranch water sources facilities, through cooperative funding from government and ranching and environmental groups. Furthermore, the conservation efforts and concerns of the private parties appear to justify the public funding and other benefits they have received.

Rancher Input into the Plan. The conservation plan will not be externally designed and imposed. Private partners will provide input into the master plan, and will participate in the specific plan proposals and implementation. They may be instrumental in carrying out habitat work and monitoring on the lands they manage.

Rancher input into frog conservation plans can include:

(1) designing the plan to fit the landscape by identifying suitable or potentially suitable habitat sites and their ecology, and identifying existing frog populations and describing their histories,

(2) identifying potential habitat problems such as water quality or accessibility, or presence of harmful introduced species, and helping design and implement solutions,

(3) identifying potential conflict between frog conservation and ranching operations, and proposing solutions to such problems,

(4) providing and regulating access to conservation sites.

In general, participating ranchers would ideally be interested parties and important resources in the design of specific area plans, and they could be key players in overall plan development.

Why Should A Rancher Participate? First, the best conservation plan will develop when participants' primary reason for participating is an interest in conservation for its own sake.

Second, there should be, practically speaking, no economic costs or risks to the rancher. The agreements will explicitly or implicitly state participants' intentions to avoid changes in policy that harm other participants or the plan itself. While it is impossible to guard against all contingencies, such a stated

intention would carry substantial weight should formal contention arise.

Third, participation will allow advantages of the conservation plan to be realized--water improvements beneficial to both wildlife and cattle, as well avoidance of Section 9 violations under the Endangered Species Act.

III. Biology and Management in the Frog Conservation Plan.

Specifics of biology and management of groups of frog populations are set forth under the present heading. In most cases, numbers and distances specified here are inferred from limited data; we don't yet have adequate information in key areas. Detailed mathematical analysis could substantially improve our estimates of what is probably required for successful frog conservation, but will still present only a range of values as recommendations for various parameters. Radiotelemetry, mark-recapture, and long term monitoring studies will prove highly informative.

The values selected here for presentation are designed to be feasible, while still providing a high likelihood for longterm success of the frogs.

The Metapopulation Concept. Each conservation plan area should have a series of frog populations connected by immigration and emigration (a metapopulation). If one localized population goes extinct, re-colonization can occur from neighboring sites. Recolonization could be done by us, although even though the objective should be to develop self-sustaining metapopulations.

Leopard frogs move many miles on their own; movements of a few (2-3) miles are definitely known, and available data points to the likelihood that movements 2 or 3 times that long may occur. The extent and frequency of these surprisingly long-distance movements is an important research topic.

People implementing the frog conservation plans may move tadpoles or small frogs within the plan area (in accordance with the plan) to accomplish the effect of re-colonization. This will be essential particularly in the early stage of conservation when populations have not yet been firmly established, or when multiple causes of decline are present.

Tadpoles or newly-transformed froglets (called "metamorphs") from existing populations or breeding facilities will normally be used as population founders.

In the area of a conservation plan, we would aim to create a system of continuous population corridors. These would be areas in which population sites would be spaced at roughly 2-4 mile intervals. The distances given here are my best guess at the time of writing, and I propose them, and the other distances presented here, for acceptance based on reasonableness, until further information becomes available.

An adaptive management model will be utilized in implementation of the overall conservation plan. It is not possible now to predict how specific plans will fare, or what outstanding opportunities will present themselves. Further, we are still learning many key parameters of the life history of leopard frogs--most notably dispersal distances, mortality during drought, normal adult and larval survivorship, and disease processes. The conservation plan should and will be adapted to reflect changes in knowledge and opportunity.

For a plan to succeed, not all landholders need to be involved, but plans would ideally involve enough area and water to sustain a metapopulation, rather than a single isolated population. However, it is also conceivable that single individuals or small landholders might develop and carry out a conservation plan even if only a single small population was involved.

Habitat Requirements for Planning. Each metapopulation plan will combine a mix of major and minor population sites, with a targeted guideline of at least one population site for each 4 - 16 square miles of corridor area. Major sites would be permanent to semi-permanent water sites of about 1/4 acre or more; minor sites would be smaller or could occasionally go dry. Major sites that are semi-permanent will be defined, unless other evidence comes to light, as those where surface or immediately subsurface moisture, clearly reachable by the frogs, is always available. As a rule of thumb, major sites should usually be within

8 miles of one another. In wet times, sites in the intervening area could support frogs, so that 8 miles overland migration would not be required.

Habitat may need to be improved before a site is suitable for leopard frogs. Generally, introduced aquatic animals would need to be removed, and sufficient water quality and permanency would need to be assured, before frogs would be brought to a site.

The more sites and participating landholders, the better. Leopard frog populations in the arid Southwest are small and fluctuating, and any one of them is subject to random extinction. Further, disease currently present in some leopard frog populations may cause local extinction events. For an area the size of the lower San Bernardino Valley, I propose that there should be at least 10 population sites, including at least 3 major sites.

Suitable Habitat and Habitat Maintenance. Leopard frogs may successfully use almost any kind of permanent or semi-permanent water that doesn't have introduced species such as bullfrogs, predatory fish, and crayfish. If a pond normally dries for a month or more per year, it probably cannot support leopard frogs except during a series of wet years. Water chemistry effect on leopard frogs are not well known at this time.

Earthen stock ponds, large steel tanks, concrete water storage reservoirs (above or below ground level), springs, and streams are all potentially good habitat for Chiricahua leopard frogs. There will be a variety of habitat types incorporated into a conservation plan for any region. Natural sites must be of special interest.

Bank vegetation may or may not be necessary or useful for leopard frogs; this is also a significant research question. An ideal situation would probably have some emergent vegetation in leopard frog habitat. Grazing might be utilized to regulate the vegetation, and to control the tendency of sites to become so choked with vegetation that open water microhabitat disappears. This might be accomplished by fencing cattle out of a part of a pond, where cattails or bulrush would grow: for this specific example, the proposal to accomplish the fencing may include a request for all of the necessary funding, since only the frogs would benefit, or some of the cost might be offered up in-kind as an inducement to potential funding agencies.

On the other hand, intensive trampling by cattle during frog breeding, especially during peak periods in March-April, September, or immediately after large rains, would kill the eggs. Partial habitat fencing may suffice for cases where cattle are likely to be using a pond during frog breeding times.

For steel or concrete tanks, water would always have to be present at a depth of about 18 inches (1/2 meter) or so, and ramps might be needed to allow the frogs to get in and out. Ramps would also have to be designed so that livestock were not injured or obstructed and other wildlife would not be entrapped or drowned.

By partial fencing and by diversifying the locations where water is available in a pasture system, it should be possible to resolve potential conflicts between cattle and needs of the frogs. The costs of achieving this compromise can be shared out according to how the benefits accrue. When the ranching operation benefits most strongly, it will be expedient for the ranch to partially subsidize the proposal; when benefits are exclusively for the frog, it will be appropriate for the work proposal to request funding to cover all costs.

Private ranch operations should not be expected to foot the bill for frog conservation without compensation if they are responsible for creating the frog habitat in the first place--whether on deeded private land or on federal or state grazing allotments.

Natural streams or springs may not need extensive or ongoing maintenance other than ensuring that grazing is at proper levels, and by using grazing schedules or partial exclosures to ensure frog reproductive success.

"Proper" grazing levels, in this context, would ensure that surface water is not eliminated by drinking, water quality remains suitable for the frogs, and egg masses are not frequently destroyed. At sites with no deep water or other refugia, grazing should be managed so that patches of vegetation remain for the frogs to escape into. Undoubtedly, factors unrelated to frog conservation will be involved in setting grazing levels.

Work to repair entrenched arroyos, which might improve grass conditions, might also raise the water table and re-activate springs that the frogs could use, at least in the long run.

If introduced species appear, they would generally have to be removed. Private ranchers participating in the plan would agree to assist by (1) discouraging wildcat releases of introduced species, (2) observing and reporting introduced species in the water, (3) offering technical advice and assistance on removal of introduced species, and (4) coordinating timing of the removal to keep it compatible with ranching operations. Private partners would agree to allow removal of introduced species. The partners would agree on reasonable precautions to minimize introduced species releases.

Costs associated with habitat maintenance for frogs (assuming the need for maintenance was not caused by the rancher in violation of the plan agreement) will be incorporated into the specific work proposals as budget items for funding. If such funding was unavailable, the private partners would not be required to assume the burden.

Earthen, runoff-filled stock ponds regularly require cleaning to remove accumulated sediment, usually at 5-20 year intervals. Costs of cleanout that are needed for the ranching operation may be offered as in-kind service proposed in specific plans proposals. In cases where special operations or modifications are required for the frogs, the proposals can request funds for these, and the ranch may thus receive some associated benefits.

Cleanout has the potential to harm frogs. An ideal solution would be to have a double-tank system in which the first pond functions as a sediment trap. This system is designed so that runoff water slows in the sediment trap, drops most of its sediment there, and mostly goes into the main pond. When the sediment trap is filled in, it can be bull-dozed out while it is dry and the main pond still has water. It is a reasonable assumption, at this time, that leopard frogs present would be in the main pond, and not the sediment trap, when the sediment trap was dry. This system might benefit the ranching operation by simplifying cleanout and making it necessary less often, and by storing more water. As such, if the plan calls for creating a double tank system, the sharing of costs could be negotiable according to the case.

If a double-tank system is not possible, other provisions would be needed for saving the frogs during sediment removal, or else the pond would not be suitable for leopard frogs. Bulldozing a dry or mostly dry pond would probably kill all the leopard frogs. Provisions to avoid this could include collecting and holding the frogs temporarily. This would only be feasible if the landholder has facilities at hand and agrees to the system, or if the public partners could guarantee the labor and facilities needed. Otherwise, there would be an unacceptable liability that could prevent the rancher from refurbishing the pond: this would also lead to loss of the frog habitat by filling and drying.

I recommend that if such ponds are to be included, the public partners agree that such liability is precluded, and that a public agency, such as the San Bernardino National Wildlife Refuge, would agree in principle to support the frog collecting and holding operations. The alternative appears to be to avoid including such ponds in any plan agreements.

Another way to maintain earthen ponds would be to have one or more large steel or concrete drinkers or reservoir tanks nearby that the frogs could go to or be put in when the earthen tank went dry or was to be cleaned out. These other drinkers could also reduce trampling and provide better livestock water than if the cattle used the earthen tank water directly.

Wells may be installed to assure or enlarge water supplies for the frogs at certain sites, and these might also benefit the ranching operation. Waters might thus be dispersed within a pasture area, allowing more even use by cattle, and reduced water level fluctuations may allow more ciénega- or marsh-like conditions to develop.

<u>Suitable Regional Units for Conservation Plans.</u> Chiricahua leopard frogs were formerly widespread in southeastern Arizona and southwestern New Mexico, but now are restricted to small populations that are isolated from each other. For example, frogs in the southern Chiricahua Mountains are now isolated from those in the lower San Bernardino Valley, and those are now isolated from ones in the Gray Ranch area.

For the species as a whole, individual conservation plans would often be based on remaining population areas. These plans, if they work, would be designed to join with neighboring plans, and to be combined with them into extensive recovered areas.

Each successful union of adjoining plans would be a major step forward toward species recovery. It is conceivable that success in a defined area could permit consideration of de-listing the species on a "recovery unit" approach. But given the frog's current straits, such speculation is premature.

Contiguous areas with existing populations naturally lend themselves to conservation planning. The lower San Bernardino Valley would be one such area, including the southern Peloncillo Mountains in the United States. If international cooperation is possible, San Bernardino Creek and Cajon Bonito would fit well into this planning area.

The San Simon Valley\Portal area is another example of a plan area that would be biologically and practically feasible. Similarly, the southern half of the Chiricahua Mountains and the associated bajadas, including Leslie Canyon\Pedrogosa Mountains, is also an area where a plan could be developed. Part or all of the Animas Mountains system might represent another planning area.

Monitoring and Evaluating the Success of Recovery. Monitoring should begin at the onset of the plan, and should establish an information baseline for the accessible area of the plan. The baseline should include the following key parameters for each translocation site, whenever such information is available or can be gathered: presence or absence of introduced species; history of the tank and historic occupancy by native and exotic aquatic vertebrates; depth; size, bank conditions; planned use by livestock (numbers, seasonality); basic water chemistry. Sites should also be monitored to observe summer-breeding toads (true toads [Bufonidae], spadefoot toads [Pelobatidae]) and predators of frogs and toads such as garter snakes and herons.

The ideal frog monitoring schedule would be approximately as follows. Sites with established populations should be monitored 1 - 4 times/year. At translocation (new population) sites, monitoring should be once per day for one week, then once per week for four weeks, monthly or quarterly for the first year, and 2-4 times/year for at least one more year. Monitoring schedules will depend on accessibility and availability of monitoring personnel. Monitoring should be most intensive during the first plans attempted, while we are still learning about leopard frog re-establishment.

Funding for monitoring will be derived from either (1) an overall budget for the master plan, (2) line items in specific work proposals, or (3) in-kind services donated by participants in the master plan or specific work proposals.

Monitoring requires access, and this may be undesirable to some private partners. The following is offered as a possible solution, should such a problem arise. Plan participants would be required to allow state or federal biologists, or their representatives, to participate in monitoring. Private partners might agree with this directly, or may seek an agreement for a non-governmental party, such as a university biologist, to accomplish the monitoring. Even then, there would still have to be agreement that state or federal biologists could verify on-site, in company of the more neutral monitor. Governmental partners involved in monitoring would assume the cost of monitoring; for university biologists, funding for monitoring costs will be supplied as described above. Private partners could also hire monitors to verify in-kind or free monitoring provided by public participants.

Monitoring would ideally be conducted, supervised, or subcontracted by participating conservation agencies such as USDA Forest Service, Arizona Game and Fish Department, New Mexico Department of Game and Fish, and U.S. Fish and Wildlife Service. Landholders (private and governmental) will be encouraged to voluntarily participate directly in the monitoring.

Monitoring will be conducted in accordance with accepted standards as described by the Declining Amphibian Populations Task Force, Arizona Game and Fish Department Nongame Branch Ranid Frog Project, or University of Arizona researchers involved in the project. There are not yet generally accepted standards for evaluating amphibian monitoring results. Amphibian populations may fluctuate naturally or as a result of human activities. Standards will be defined by an oversight and advisory committee, or specified

in specific work proposals submitted for funding.

Oversight of the Plan and Monitoring. The frog conservation plan will have an oversight and advisory committee and/or project managers selected by the participants, and acceptable to a majority of both the private and public partners. The committee will include (funding permitting) representatives from academic, ranching, and governmental participants (biologists, managers, and private participators). The managers, if chosen, may be anyone agreed upon as above.

The simplest way to chose managers would be for the committee to select a chairman, identify a core working group, and structure the working group according to needs dictated by the plan.

It is not necessarily true that each plan would require a large committee. If frog conservation plans develop in several regions, agencies will undoubtedly develop a standing committee to interface with local planners and field-active participants. Project managers and key field-active participants will certainly need to be a small number of persons.

For the MBG area plan, which would be the first of this kind, the oversight committee will arrange for keeping records of key events in plan activity, advising and deciding on progress of management, and evaluating success of the plan. I expect that progress would allow most of these and similar functions to be dispersed to managers and field-active personnel for specific conservation plans.

A timely flow of information about progress of and adherence to the plan, and from the agencies to the plan participants about agency views and concerns will be essential to public-private cooperation here.

I don't believe there is a magic formula to evaluate plan progress and success. Evaluation should be based on monitoring results, sound biological reasoning, and common sense. More precise criteria for evaluation of population viability and adequacy of conservation will eventually be available.

IV. Legal Issues and Protections for Participating Parties.

Value of Agreements to Public and Private Parties. Specific plans, within the overall (master) conservation plan, may be developed formally or informally as situations dictate. Informal agreements may allow participation of persons unwilling to sign formal agreements, although they would not provide the clear funding and responsibility definitions that the work proposals will contain. Assuming a Special Rule is in effect, it will likely protect all ranchers to some extent, regardless of their participation. Formal and signed agreements will more clearly protect both private parties and conservation interests from improper damage to populations of threatened species.

The specific plan proposal will state what each participant is expected to do, both specifically and in spirit. Participants must ensure that what is agreed upon is sufficient for their various needs. Plans will be subject to reasonable changes, even substantial ones, based on new circumstances and facts, in the spirit of the agreement, and on approval of participants.

For each specific plan involving a participating ranch or group of co-signing ranches, the work proposal will state the sites to be used by frogs, how these places are to be modified, and how they are to be used and monitored. The amount of detail written up in the proposal is up to the participants. Private parties thus would not be liable for additional actions or costs that might arise, although they would agree to good-faith efforts to sustain the frog population(s) in the context of the conservation agreement.

Private parties could also initiate an expansion of the conservation agreement, if they so desired. This might be as a way to obtain additional or enhanced water developments beneficial to the frog conservation and to the ranch for whatever reason. For example, a rancher interested in a new well or sediment trap might propose to integrate the operation within the frog conservation plan activities. For an already-funded and under-way work plan, this would be accomplished by an amendment agreed to by participants and the funding source.

The USFWS is unable to enter into any agreement it cannot unilaterally exit, due to potential changes in funding, authorities, etc. Unilateral termination is normally an option for all parties in conservation

agreements. Signatories to a frog conservation plan should understand the sense of the agreement, and that if they unilaterally exit, they cannot impose liabilities on remaining partners that resulted from the participation of those partners in the plan.

Thus, for example, USFWS would agree not to renounce agreements and exemptions pursuant to the plan. Similarly, private parties unilaterally exiting the plan could not necessarily expect to enjoy the protections or exemptions they gained as participants in the plan. If they were unilaterally terminated, such as for the convenience of developing housing, exemptions from Endangered Species law could terminate as well.

Status of Managed Populations Under USFWS Special Rule. It is anticipated that federal listing of the Chiricahua leopard frog (*Rana chiricahuensis*) as threatened under the Endangered Species Act will include a special rule designed to facilitate cooperation of ranchers and conservationists.

Although there has recently been a move against legal designation of "experimental non-essential" status for conserved populations, the special rule will enhance freedom of action within the conservation plans.

Many or most populations on ranches under the plans will be newly-established or re-established. Practically speaking, each new and managed population will be an experiment. Events such as air pollution or disease will probably influence the success of populations of concern. Furthermore, each local population will be part of a metapopulation. Management strategy will be to maintain metapopulation viability, rather than to preserve each constituent population regardless of cost.

This treatment of individual populations could also be beneficial for public conservation agencies. Managed populations in water developments are subject to various unpredictable effects, including from frog management. If the agencies are required to treat each population and its individuals as essential and inviolate, active management will be unable to keep pace with frog population dynamics and species declines: successful active management will not be possible. Thus, conservation agencies and efforts will benefit from cooperation on private and public ranchland, and from the managerial flexibility inherent in the approach proposed here.

Specific Forms of Population Status. There will be three levels of population status within the context of this planning process: (1) Natural Populations (which may be essential or marginal), (2) Experimental Managed Populations, and (3) Established Managed Populations. These categories may clarify thinking in developing the conservation plan. They may also clarify the use of the special rule.

"**Essential Natural Populations**" are defined as known, pre-existing, reproducing populations on federal land, that have a reasonable chance of viability. I suggest the following guidelines for likely viability: average of more than 8 regularly countable adults or 25 individuals of a mix of at least three life stages [egg masses, sizable tadpoles, juveniles, and adults]). These would be core populations with high management priority, and frog conservation plans must focus on sustaining or enhancing them. Marginal populations in natural habitat will be evaluated based on their potential function as links in the metapopulation structure.

Essential Natural Populations must be treated with special care to ensure that heavy-handed management for ranching or conservation purposes does not alter the conditions favorable for frogs. Leslie Canyon National Wildlife Refuge, and perhaps other sites, may be included in this category.

Essential Natural Populations and their habitat have three key roles: (1) as core areas for managed metapopulations, (2) sources of eggs for head-starting, and (3) as centers for understanding and maintaining the natural adaptations to environment that make the Chiricahua leopard frog ecologically and evolutionarily unique.

Without essential natural habitat, the ecological and evolutionary *raison d'être* of the Chiricahua leopard frog will not exist. Maintaining its longterm identity and viability will be a chimera, and perpetual management in artificial habitat would be its lot and demise. Protecting essential natural habitat, and identifying critical habitat in natural springs and streams, are, in my opinion, clearly warranted in this case.

Newly established populations should be regarded as "**Experimental Managed Populations**" and the habitats they occupy should be viewed as of unproven quality until they are successfully occupied for a

period of 10 years. Since such populations may fail for a variety of un-anticipated reasons, it would be unwise to assign them high priority for remedial measures.

After 10 years, Experimental Managed Populations that are stable and successful can be viewed as having an intermediate status: "**Established Managed Populations**". Unexpected declines in these populations should be regarded as potentially indicative of novel or serious factors of decline. Agreements for research or remedial action might then appropriately be sought.

Experimental and Established Managed Populations will be treated as follows. Normal and flexible ranch maintenance will be permitted. The incidental killing of a fraction of frogs (1-25%), working within a conservation plan, at one locality within a metapopulation will normally be considered acceptable as agreed upon in the original plan (the range 1-25% is arbitrary and intended as a guideline only). The special rule in the federal listing package of the Chiricahua leopard frog will probably authorize any level of take that is consistent with the conservation plan. Take at and above 25% would most likely cause a close inspection of how things were being done, and how the take could be reduced.

Under the **Managed Populations** designation, if the conservation plan calls for putting frogs into a tank without a sediment trap, and the tank needs to be cleaned out, it would be the responsibility of the rancher to inform the conservation agencies of the impending operation (in a timely fashion), and the responsibility of the agencies to collect and hold the frogs for later release or to do nothing. The rancher would not be required to take extraordinary actions in case of drought to maintain water levels, but would allow the agencies to do so if they so desired.

Contingencies Resulting From Frog Population Events. It is worth considering scenarios that might lead to disagreements or mistrust among participants. This may focus attention on the importance of basing the frog conservation plans on good faith. At the very least, this discussion should make participants aware that biology is complicated enough, and legal issues uncertain enough, that a "good faith approach" is probably the only one that can yield a sound and reliable agreement.

What follows are some scenarios I consider without implying ethical guiltiness more specifically than for all of us as human beings. These are possible scenarios that might be avoided by fore-awareness.

(1) The overall conservation plan will remain in force as long as at least two of the major population sites contained frogs and appeared likely to remain viable, and minor sites existed in the continuous swath (corridor) of landscape. "Viability" would be according to professional biological analysis and common sense, in case of disagreement: frog population viability analysis is not likely to soon become an exact predictive science. The basis for evaluation of viability should be indefinite population persistence under reasonable assumptions for habitat quality and management, within the known contexts of frog population dynamics.

(2) Specific work plans will have a duration of five years, during which habitat work and monitoring will be carried out. After that, population monitoring may be continued by any of the participants that will supply the necessary support, or the participants can simply negotiate project extensions or submit for additional funding. Any rights and responsibilities derived and agreed to would be part of the overall (master) plan for the metapopulation area, and would have their duration determined by the overall plan's life.

(3) If the conservation plan metapopulation were reduced to just one single "viable" population without expectation that recolonization of other sites would occur, the conservation plan will have to be re-worked. Special Rule designations dependant upon the existence of a conservation plan would lapse, unless (a) participants agreed that extrinsic factors (e.g., pollution, UV-radiation, disease, uncontrollable vandalism) made the project un-workable and thus moot, or (b) a new conservation plan were devised, or (c) the species was de-listed because it had recovered sufficiently. This will discourage private parties from setting up conservation plans and then facilitating disappearance of the frogs.

(4) If the frog population in a conservation plan area goes extinct as a whole (that is, the entire area *en toto* no longer supports a viable population), habitats where frogs went extinct will not continue to be treated with the status they may have had under the conservation plan. Thus, private persons would not be encouraged or allowed to get such status and then cause the frogs to die out. The frogs could possibly re-

colonize on their own from other recovery areas, and there would be no justification then to revert automatically to exempt status. Again, this would discourage malfeasance without adding any onerous rules for private participants.

(5) On the other hand, if a local population disappeared for whatever reason, re-introduction or re-colonization could re-establish its Special Rule and conservation plan status. Assuming that good habitat still existed at a local population site (even though the local population disappeared due to, for example, normal fluctuations, unusual drought, pollution or disease), a single participants could not unjustifiably block re-establishment. This would avoid the scenario in which someone, having gotten the benefits, decided a frog population was expendable and caused its elimination.

(6) Finally, if a local population site became un-inhabitable through no fault of the landholder, such as by filling in with sediment, by air pollution, or by criminal vandalism, the landholder would not be responsible for rehabilitating the site for frogs. Conservation agencies could restore such a habitat to earlier or better condition, such as by cleaning out sediment or eliminating pollution or introduced species. If so, the site would again have its original status with regard to the endangered species rule and conservation plan.

V. Preliminary Outline of Plan for San Bernardino Valley Area.

At this draft stage, the conceptual plan is under review. Specifics about various landowners' habitat, plans, etc., are excluded until both public and private partners agree in principle. I have already incorporated review comments from key USGS, USFWS, and AGFD personnel. Once private parties and others have examined this document, and offered changes, I will submit the final to USFWS and AGFD, and site-specific and landholder-specific plans and schedules can be initiated with MBG members.

Conservation Planning Regions and Cooperators. Four initial conservation plan areas can be envisioned for the area of the Chiricahua, Peloncillo, and Animas Mountains and the San Bernardino, San Simon, and Animas Valleys. These four areas are based on the current isolation of four sets of populations in this region: (1) the Swisshelm-Pedrogosa-southern Chiricahua Mountains area, with a core population at Leslie Canyon NWR, and known or suspected cattle tank populations in the area; (2) the northern Chiricahua Mountains with two populations near Portal, another in North Fork and Horsefall (Pinery Canyon), isolated records in other drainages nearby, and likely key cooperation from the Southwestern Research Station; (3) the lower San Bernardino Valley-southern Peloncillo Mountains area with the San Bernardino NWR functioning as a core population area and primary base of operations for all 4 plans, and with Magoffin Ranch and other Malpai Group cooperators setting the precedent in development of detailed agreements and forward progress; and (4) Gray Ranch area near Animas Mountains where two known Chiricahua leopard frog populations in southwestern New Mexico are found (Gray Ranch and adjoining ranches in the Peloncillo Mountains would also be potential participants in conservation plan area [3]).

Key cooperators would be (1) ranchers from the Malpai Group and Animas Foundation, (2) USDA Forest Service (Coronado National Forest, Douglas Ranger District), (3) Arizona Game and Fish Department, (4) New Mexico Department of Game and Fish, and (5) U.S. Fish and Wildlife Service Ecological Services Offices (Phoenix and New Mexico); San Bernardino/Leslie Canyon National Wildlife Refuges). Additional key cooperators should or could include (6) other ranchers, (7) the Arizona State Lands Department, (8) the City of Douglas (Douglas High School), (8) Phoenix Zoo, (9) Arizona-Sonora Desert Museum, and (10) the U.S. Bureau of Land Management. Finally, (11) Mexico, and landholders there, may also possibly cooperate actively in conservation planning in this region.

Agreements should seek to include the following parties, all of whom have expressed at least some interest in participating in leopard frog conservation: USDA Forest Service, Glenn (Malpai) Ranch, Gray Ranch, Seth Hadley's Ranch, Magoffin Ranch, McDonald Ranch, Miller (Post Office Canyon) Ranch, Scholes (Research) Ranch, and Woodling's Ranch. Other parties with strategically-placed lands, who should be contacted early in the planning and management process include Peterson Ranch, Snure Ranches, and Krentz Ranch.

Discussion should also be initiated with landholders in the Cloverdale Creek area, where Chiricahua leopard frogs are historically known or suspected to have occurred, to attempt to find a satisfactory agreement for them. Ranchers in this area have been especially mistrustful of private and public ranch

reform progress, and their concerns should be carefully respected, and if possible, addressed.

Lower San Bernardino Valley Planning Area. In the following section, an outline is presented for the lower San Bernardino Valley region, including the southern Peloncillo Mountains and their bajada. When both public and private partners have agreed conceptually, the overall master plan will be completed. At that time, funding will be sought for development of specific work proposal plans at specific subareas, ranches, and aquatic sites. Funding will be sought for the proposals and work will begin whenever funding needs can be satisfied.

This region has the benefit of the Malpai Borderlands Group, Animas Foundation, San Bernardino National Wildlife Refuge, and a history of active frog conservation work involving private, state, federal, and university personnel. This should be a model area for development of Southwestern ranid frog conservation plans.

The base area for this plan will be the San Bernardino National Wildlife Refuge. There are several reasons for this: Chiricahua Leopard frogs are established there in a bullfrog exclosure; another exclosure exists, and additional exclosure populations are planned; a building for frogs ("ranarium") is operational; and the public agency (USFWS) is likely to accept the attendant responsibilities. Finally, managerial personnel for this refuge also oversee and manage the Leslie Canyon National Wildlife Refuge, which supports an important natural-habitat-based population of Chiricahua leopard frogs.

In the final conservation plan, San Bernardino National Wildlife Refuge may commit to (1) maintaining leopard frog populations, (2) cooperating in the production of tadpoles for translocation, (3) collaborating on research related to leopard frog conservation and re-establishment, and (4) assisting the planning and conservation process in various other feasible ways.

The Arizona Game and Fish Department may designate the conservation plan area as a Conservation and Management Zone and participate in the planning process, or, develop a Memorandum of Understanding, allowing participants in the conservation plan to pursue active management while maintaining a consultative relationship with AGFD. The oversight committee or its representative will pursue development of these key relationships of the conservation plan with USFWS and AGFD.

Habitat Management Activities. Ponds currently containing sunfish, bass, mosquitofish, and possibly other introduced species may be converted to use by native species. Comment will be sought from NMDGF, AGFD, and those currently utilizing the ponds. Three or more sites on ranch lands that now have non-native fish appear suitable as major breeding population sites for native aquatic species.

Areas where introduced fishes have been removed might also be considered for native fishes that leopard frogs are most likely to be compatible with, such as beautiful shiners (*Cyprinella formosa*), Yaqui topminnows (*Poeciliopsis occidentalis sonoriensis*), or, in some drainages, longfin dace (*Agosia [=Rhinichthys] chrysogaster*). It will be the responsibility of the oversight committee and plan manager to establish clear lines of communication with fish conservation personnel at the agency and university level to explore this option.

The absence of Chiricahua leopard frogs in many ponds in the New Mexico portion of the Malpai Borderlands is not well understood, and may reflect unexplained disappearance during the late 1980's that occurred in numerous cattle ponds in southwestern New Mexico. Research in this area may related to disease processes in this species may be appropriate: such research should be integrated into the conservation plan monitoring program.

Small aquatic sites involving concrete and steel tanks may be set up so that leopard frogs could utilize them, to determine whether they can sustain frogs. This may involve (1) maintaining water in the tanks, and (2) creating or maintaining small wet areas on the ground near these tanks or their windmills. If this is successful, the conservation plan should seek to ensure maintenance for the windmills and associated water tanks.

A population or populations may be established in small grassland tanks with associated drinkers, and large concrete tanks may also be used, if funds can be secured for relatively minor modifications, such as (1)

partial livestock exclosure fencing for a pond or ponds, (2) renovation of piping and similar hardware, and (3) design and installation of ramps and obstructions to permit frogs to get in and out of large concrete tanks, while protecting other wildlife and cattle from injury and drowning.

Point (3) would represent a major step in prototype design for using large, aboveground concrete tanks, which are very abundant and have clean water, for leopard frog population sites. Chiricahua leopard frog populations are known from this kind of habitat.

Sources of Leopard Frog Stock for Translocations. Tadpole rearing at Douglas High School and other schools in Douglas, Arizona, should continue as part of the conservation plan. AGFD should continue to approve of this, and USFWS should reaffirm it cooperation with this program after listing occurs. In addition, larger scale breeding or tadpole growout agreements should be sought with one or more zoo or museum facilities in Arizona, such as at Arizona-Sonora Desert Museum and Phoenix Zoo. The oversight committee and conservation plan manager will facilitate the process of integrating this and other potential rearing operations with the listing status of the Chiricahua leopard frog.

Tadpoles for these operations, and potentially also for translocations, may be harvested from enclosed populations at San Bernardino National Wildlife Refuge; tadpoles may also be taken from sites that appear to have enough individuals to sustain limited withdrawals. It will be necessary to ensure that disease is not transmitted to new population sites, to the extent that this can be accomplished by (1) avoiding translocations from sites where chytrid fungus disease has been detected or is suspected, and (2) tank-rearing tadpoles from portions of harvested egg-masses.

Oversight Committee. All signatories and participants to the plan will be represented (or at least have the opportunity to be represented) on the oversight committee. Participation on the oversight and advisory committee for this frog conservation plan will be available to representatives from University of Arizona, San Bernardino National Wildlife Refuge, the Douglas public school system, U.S. Fish and Wildlife Ecological Services Office, Arizona and New Mexico Game and Fish Departments, USDA Forest Service, Douglas High School, and participating private ranches, and other concerned agencies. Invitations to participate will also be extended to zoo personnel, Bureau of Land Management, and Arizona State Lands Department. The committee should elect a chairman and should have a core working group with a field-active focus to direct management activities. The chairman and management-active portion of the committee should communicate regularly and in a timely way with other committee members as appropriate.

RESURVEY OF THE MEXICAN GARTER SNAKE (*THAMNOPHIS EQUES*) IN SOUTHEASTERN ARIZONA

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Abstract

Mexican garter snake (*Thamnophis eques*) populations in southeastern Arizona were re-surveyed during 2000, with additional information collected during 1993-2001, at localities known to support the species during the early-mid 1980's. At the most intensively studied site, San Bernardino NWR, there was a major, systematic decline; at a second intensively studied site, Finley Tank at Audubon Research Ranch, there was also a major decline that was probably both systematic and a product of natural climatic variation. Systematic declines have been associated with high-density bullfrog populations, predatory centrarchid fishes, and disappearance of primary prey – native ranid frogs and native fishes. At a third study site, Scotia Canyon in the Huachuca Mountains, capture rates were highest in 1980-1982, lower in 1993, and lowest in 2000, although sample sizes were small. Among remaining sites, favorable results were obtained at 3 and unfavorable results at 13. The most encouraging result was an apparent increase at Ciénega Creek County Preserve, along with persistence at Empire-Ciénega Ranch. An extensive, it not abundant, population was documented in the lower San Raphael Valley. The third piece of good news was rediscovery of the Mexican garter snake at Arivaca Ciénega, although it remains rare there. In summary, findings are: increases suggested at 1 site (lower Ciénega Creek), possible stability at 2 (lower San Raphael Valley, Arivaca), negative trends or findings at 14 (Empire-Ciénega Creek, Babocomari, Bog Hole, O'Donnell Creek, Turkey Creek [Canelo], Post Canyon, Scotia Canyon, Lewis Springs [San Pedro River], San Pedro River near Highway 90, Barchas Ranch Pond [Huachuca Mountain bajada], Heron Spring, Sharp Spring, Elgin-Sonoita windmill well site, and Upper 13 Reservoir [San Raphael Valley]), and major, demonstrable declines at 2 sites (San Bernardino NWR, Finley Tank), with no documented extinctions. The Mexican garter snake was found to be in widespread, ongoing decline in southern Arizona.

Introduction

The Mexican garter snake (*Thamnophis eques*) was surveyed in Arizona during 1985-1988, at which time it was found to be declining markedly, with remaining strongholds in Ciénega Creek at Empire Ranch, the Canelo Hills and adjoining Sonoita Grasslands, and parts of the San Raphael Valley, in Pima, Cochise, and Santa Cruz counties (Rosen and Schwalbe, 1988). It was thought to be declining and uncommon or rare elsewhere in its range in the United States, which formerly included natural perennial waters in Sub-Mogollon Arizona (including the Colorado River below Grand Canyon) and extreme southwest-central New Mexico. Other than the obvious loss of riverine and ciénega habitat, the principal cause of decline identified was predation by non-native species that have been widely introduced in Arizona. This factor was most clearly identified at San Bernardino National Wildlife Refuge (SBNWR), in Cochise

County, where, as in many areas, the bullfrog (*Rana catesbeiana*) was identified as the primary predator causing decline.

Along with attempts to eliminate or control the bullfrog at SBNWR, an intensive garter snake monitoring and mark-recapture program was carried out 1985-1989 and 1992-1999 (Rosen and Schwalbe 1995, 1996, 1997, 1998; 2002 *in press* and *this report*; Schwalbe and Rosen, 1988). Local situations where the bullfrog was controlled yielded successful recruitment, but the control was transitory, and the decline of the Mexican garter snake continued, as predicted, toward extirpation through 1999. This species was found to be relatively long-lived once individuals reach sizes too large for bullfrog predation; this slows the decline, and also potentially masks it. There are probably still a handful of these snakes at or near SBNWR.

The original survey work in 1985-1988 was done just after a major wet period in southern Arizona (1977-1984), and it was suspected that relatively good garter snake capture rates, which were obtained at a number of localities, might reflect temporary, climate-related flushes. Here we discuss re-surveys of key localities carried out primarily in 2000. Two sites where live-trapping and mark-recapture work were previously done, Finley Tank at the Audubon Research Ranch (1985-1988; Rosen and Schwalbe, 1988) and Scotia Canyon in the Huachuca Mountains (1993; Holm and Lowe, 1994) were re-trapped following original protocols, with reduced capture rates in both cases.

Other localities that were less intensively sampled in previous years were also re-surveyed, using a combination of hand-capture and trapping efforts. Details of the field work at all sites (except San Bernardino, for which details can be found in other reports and elsewhere in this report) are presented in gazetteer form in Appendix I.

Methods and Materials

I. Localities Re-Surveyed.

We attempted to reach all recently known or suspected recent localities for the Mexican garter snake in southern Arizona at some point during 1995-2000. We will not here further discuss areas that are highly unlikely to support the species without active management: Santa Cruz River at Tucson, Tucson Basin including Agua Caliente Springs, La Cebadilla Spring, Fort Lowell and vicinity, lower San Pedro upstream to and including Fairbank, Potrero Canyon and Potrero Creek at Nogales. We visited all of those localities doing other work during recent years and in each case looked for Mexican garter snakes to no avail. At Nogales, a 1980 vintage observation near Rio Rico has never been adequately re-investigated, but there remain no subsequent records from there and an exact locality is not available. We also did not re-investigate Sonoita Creek, still a possible population site although there are no records for many years. They might appear at these sites yet, especially at the last five, but the probability of finding one in a general site survey of a visit or two is extremely small. As described below, there is a clear expectation that even if the species remains at any of these sites it would be and can be expected to remain quite rare.

We focused first on localities for which quantitative data on abundance was previously available: San Bernardino National Wildlife Refuge, and Finley Tank on the Audubon Society's Appleton-Whittell Research Ranch at Elgin (Rosen and Schwalbe, 1988, 1995, 1996, 1997, 1998, 2002 *in press*), and Scotia Canyon in the Huachuca Mountains (Holm and Lowe, 1994). We also attempted to visit known localities in the San Raphael Valley, Canelo Hills, Sonoita Grasslands, Babocomari, and Ciénega Creek – the core of the species population in the U.S.A. as

previously identified. Finally, we re-surveyed Arivaca Ciénega and sites on the San Pedro River and Huachuca Mountain bajada for which relatively recent records were available.

II. Survey Methods.

We followed previously established methods (Rosen and Schwalbe,1988) for trapping and on-foot survey for garter snakes, and will only briefly restate them here. Trapping was done using short (3 - 5 m long) 1/8 inch mesh hardware cloth as drift fences set in the water, with a standard commercial galvanized steel minnow trap set at each end. The minnow trap entrance was opened to a diameter of 3-4 cm, and the back funnel was pinched shut, and the trap was wired to a V-shaped set of 1 m long fyke wings at the end of the drift fence (thus, the trap layout resembles a line with an arrow at each end). The funnel entrance to the minnow trap was set at or slightly below water level, although changing water levels sometimes altered this desired situation. These traps were not baited but accumulated aquatic animals that served as bait (although they caught many more snakes than found in traps that baited themselves but lacked drift fences or wings). In case the minnow traps should be exposed to full sun, they were draped with whatever was available to prevent overheating. They were checked on a daily schedule.

Traps were set in water 10 - 80 cm deep, most often near shore with a "deep' and a "shallow" end, and the V-shaped fykes were designed to match differing water depths (by putting a trapface-sized hole, where the trap was attached, at varying heights on the hardware cloth). The central drift fences were, when possible, set at an oblique angle to shore, so that one wing of the V-shaped fyke intersected the shore at slightly less than the perpendicular. Although we attempted to set traps in the most auspicious sites, trap location was often determined on a small scale by where one would fit through vegetation and where appropriate water depths were available. Especially in streams, it is difficult to situate these traps properly, due to deep water at undercut banks, small, narrow pools, and various other irregularities of depth and substratum. The time traps were set and broken down, and the number and location of those set, were recorded on datasheets or in the field notebook.

On-foot searches were carried out primarily during daylight hours. They consisted of walking quickly through the best habitat at each site, that generally being along the edge of pools, streams, and ponds. If possible, every opportunity was taken to follow trails or use narrow open areas to travel on and see snakes on. When moving, we listened for the sound of snakes fleeing in dense vegetation, as well as watching for basking or fleeing snakes. In dense habitat it is important to move quickly enough to be upon them before they have time to move quietly out of sight. We also used sit-and-watch tactics at pools or ponds, and stalked quietly through the habitat looking and listening for snakes and anurans or looking under loose surface cover. Under some conditions, we moved slowly, quietly, and used binoculars to search for basking snakes in cool early morning hours. Start and stop times, habitat searched, and search procedures were recorded in field notebooks and on data sheets.

Surveys were carried out during April-October, but generally during May-September during warm weather. Snakes found during on-foot searches were caught by hand or occasionally with a dipnet or snake tongs, and habitat conditions were recorded with reference to water depth, distance to water's edge, cover, vegetation structure, floristics, and insolation. Captured snakes were sexed by examination or with reptile sexing probes, held straight against a steel tape to measure snout-vent length (SVL) and tail length in millimeters, and weighed to the nearest 1 % on a set of spring balances (10 g, 100 g, 1000 g) that were regularly checked to maintain calibration. At most sites, snakes were scale clipped with an individually-unique subcaudal mark (by removing ½ of the subcaudal, the entire adjoining scale of dorsal scale row 1, and ½ of the

adjoining scale of dorsal scale row 2: except in neonates, this always left a mark readable by a very attentive and careful worker), and a PIT tag was implanted (in snakes 325 mm SVL and over) under the skin in a lateral position anterior to the tail base. Snakes were also examined for scars, injuries, or tail breaks, reproductive condition, and presence of conspicuous food bulges. They were released at the capture site, generally within an hour or less of capture or removal from trap.

Data was maintained in Excel spreadsheets and analyzed in Excel or with PCSAS (SAS Insinuate, 1990) according to standards described in Sokal and Rohlf (1995).

Results and Discussion

I. Population trend at San Bernardino National Wildlife Refuge

Garter snakes were studied 1985-1989 and 1992-1999 at SBNWR, and trapping was carried out on 192 days, for a total of 2,440 trap-days (24 hr basis). All told, 1192 garter snake observations were recorded (148 *T. eques*, 1014 *T. marcianus*, plus 30 for which species determination was not possible; Table 1), along with many other snakes (Appendix II). The steady decline of the Mexican garter snake at SBNWR reported through 1997 continued to the end of our trapping program in 1999 (Table 1). The last verified record for the Mexican garter snake is in 1999, although it is to be expected that a few remain on-refuge or may disperse from adjoining Rancho San Bernardino in Mexico. Refuge personnel have reported a single sighting

Table 1. Observations (captures, shed skins, carcasses, visual observations) and standard trap capture rates of garter snakes (*Thamnophis eques, Thamnophis marcianus*) at San Bernardino National Wildlife Refuge, Cochise County, Arizona. Other garter snakes, which escaped without species determination, are not included.

	Total Observations (all observation types)			Standardized Capture Rate (captures / trap-day)		
YEAR	*T. eques*	*T. marcianus*	Total	Trap-Days	*T. eques*	*T. marcianus*
1985	2	3	5	0		
1986	8	5	13	30	0.067	0.033
1987	9	7	16	12	0.083	0.083
1988	12	6	18	23	0.000	0.000
1989	12	21	33	16	0.126	0.063
1992	10	10	20	24	0.248	0.083
1993	20	64	84	200	0.080	0.250
1994	14	69	83	134	0.060	0.150
1995	31	222	253	490	0.057	0.365
1996	9	160	169	315	0.022	0.479
1997	16	151	167	315	0.048	0.349
1998	4	162	166	421	0.007	0.275
1999	1	134	135	459	0.002	0.233
Total	148	1014	1162	2440		
Mean	11.4	78.0	89.4	203.3	0.0365	0.3025

each in 2000 and 2001 but no photographic documentation is available. Due to the rarity of the snake, few are practiced at distinguishing Mexican and checkered (*T. marcianus*) garter snakes: photo documentation is essential, and any reasonable photo can be used to confirm identification at known localities.

Results presented in Table 1 show a marked decline in the Mexican garter snake, as will be seen in further analysis described below. However, they suggest a massive contemporaneous increase in the checkered garter snake, suggestive of an interspecific competitive effect, that requires careful evaluation. The trap-capture rates (Table 1) suggest that *T. marcianus* was less abundant than *T. eques*, at least in the water (where the traps were), prior to 1993, whereas the situation was reversed from 1993-1999 due to a massive increase in *T. marcianus* and the simultaneous, steady decline in *T. eques*. It is useful to collapse the data into these two time periods because annual sample sizes were individually too low to be reliable in 1985-1989. Thus, capture rates for *T. marcianus* went from 0.06 to 0.31 captures/trap-day, a 5-fold increase, while for *T. eques* they went from 0.13 to 0.03, a 4-fold decline. This trend in trap-capture rates is real, and holds up within ponds and regardless of how the data is grouped.

However, interspecific competition by reduction of food base seems to be an unlikely scenario at SBNWR, with capture rates less than 1/4 the rate of the 1.42 per trap-day seen at another study population where resource depletion may indeed have occurred (see below); the abundance of small fish, bullfrog tadpoles, and small bullfrogs was high throughout the study at SBNWR. Further, the trap-capture rate is not in accord with overall capture rates and mark-recapture results for *T. marcianus*. It appeared from the beginning of study that *T. marcianus* was just as visible as *T. eques* at SBNWR, even though our focus of study was on the latter. Furthermore, we were surprised to obtain recaptures for *T. eques* and puzzled that none were simultaneously obtained for *T. marcianus*. In 1985-1992, 49% (21 of 43) of hand captures of *T. marcianus* were away from wetlands, compared with 19 % in 1993-1999 (Fig. 1, $\chi^2 = 11.38$, $df = 1$, $p < 0.001$). This snake naturally utilizes ephemeral ponds and pools in Arizona's desert grasslands (see Rosen and Schwalbe, 1988; and Woodin, 1950).

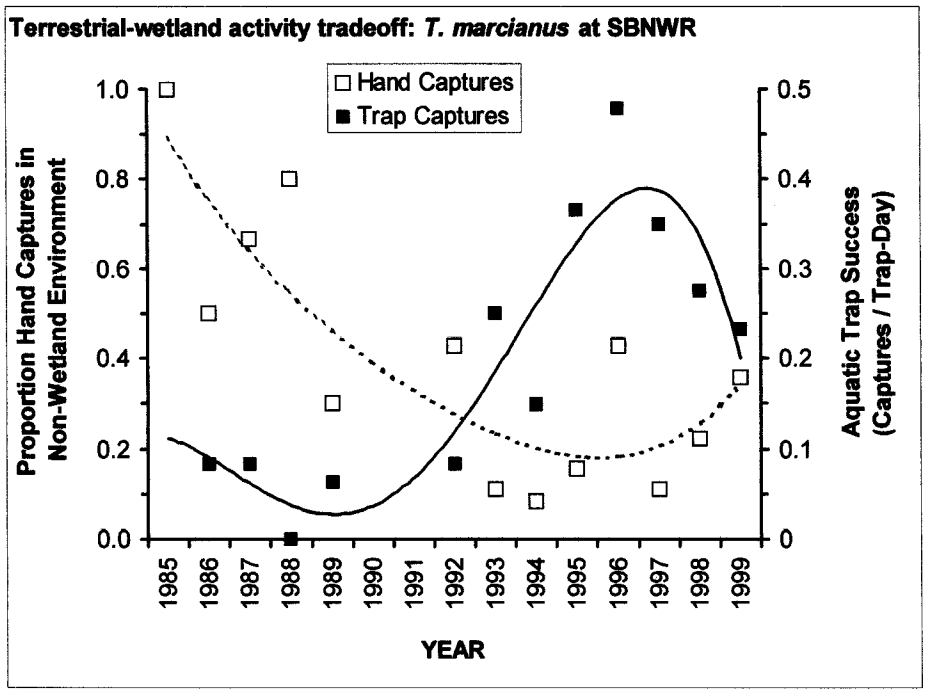

Figure 1. Use of terrestrial and wetland habitats by *Thamnophis marcianus* at San Bernardino National Wildlife Refuge, Arizona. Captures > 2 m away from ponds, stream pools, and their surrounding bog and marsh environs were classified as terrestrial activity, while other captures were classified as wetland activity. Ephemeral pools and puddles occupied by anurans are included in the terrestrial category. No sampling was done in 1990 and 1991. Points are arbitrarily fitted with 4th-order polynomials to illustrate trends.

At the perennial wetland complex at SBNWR, *T. marcianus* was found at ephemeral puddles feeding on juveniles bullfrogs and larval Couch's spadefoot (*Scaphiopus couchii*). However, in the 1980's individuals were found active in mesquite woodland away from water, not clearly engaged in foraging for anurans, nor in simple dry-land sheltering. Whatever its purposes, terrestrial activity was more conspicuous, and proportionally decreasing, from 1985-1992 as drought accentuated following the heavy rains of the early-mid 1980's.

On this basis, I computed capture rate for garter snakes at SBNWR based on sampling effort defined as a simple addition of days worked (to represent manual capture effort) and trap-days (Table 2). The Mexican garter snake (Table 2A) suffered a decline to near extinction by 1999 at SBNWR. There is an indication of a transitory increase during 1989-1992 associated with successful recruitment in bullfrog-free sites and following emigration from Black Draw to trapping areas in North Pond and Twin Pond during drought (Rosen and Schwalbe, 1995, 1998). Lumping the sparse annual samples from 1986-1992 gives a mean of 0.2 captures/unit effort, reduced to about 0.05 in the mid-1990's and 0.01 or less in the late-1990's, suggesting a relatively steady decline (Fig.2).

Table 2A. Site-specific capture rates per unit effort (trap-days + hand capture days) for the Mexican garter snake (*Thamnophis eques*) at San Bernardino NWR.

YEAR:	1986	1987	1988	1989	1992	1993	1994	1995	1996	1997	1998	1999	Mean
Robertson Ciénega								0.15	0.02	0.03	0.02		0.05
North Pond	0.20	0.11	0.06	0.26	0.24	0.09	0.00	0.05	0.01	0.01	0.00		0.09
Twin Pond	0.30				0.48	0.12	0.12	0.07	0.05	0.13	0.02	0.01	0.14
Evil Twin						0.04	0.15	0.03	0.03	0.05	0.02	0.00	0.05
Double PhD								0.00	0.00	0.00	0.00	0.00	0.00
Bathhouse Well								0.00				0.00	0.00
Mesquite Pond											0.00	0.00	0.00
Oasis Pond												0.00	0.00
ANNUAL MEAN	0.25	0.11	0.06	0.26	0.36	0.08	0.09	0.05	0.02	0.04	0.01	0.001	0.112

Table 2B. Site-specific capture rates per unit effort (trap-days + hand capture days) for the checkered garter snake (*Thamnophis marcianus*) at San Bernardino NWR.

YEAR:	1986	1987	1988	1989	1992	1993	1994	1995	1996	1997	1998	1999	Mean
Robertson Ciénega								0.33	0.50	0.31	0.37		0.37
North Pond	0.10	0.33	0.11	0.61	0.36	0.07	0.10	0.23	0.22	0.15	0.08		0.22
Twin Pond	0.20				0.16	0.17	0.14	0.46	0.57	0.51	0.25	0.19	0.30
Evil Twin						0.79	0.30	0.61	0.70	0.82	0.85	0.12	0.60
Double PhD								0.69	0.32	0.27	0.43	0.27	0.39
Bathhouse Well								0.16				0.15	0.16
Mesquite Pond											0.48	0.38	0.43
Oasis Pond												0.32	0.32
ANNUAL TOTAL	0.15	0.33	0.11	0.61	0.26	0.34	0.18	0.42	0.46	0.41	0.41	0.24	0.33

Similar lumping for the checkered garter snake suggests relative stability in this species, with long-term data for North Pond (decline) and Twin Pond (increase) showing opposite, though not extreme, trends (Table 2B). Very high capture rates were found in new or newly re-wetted ponds in the 1990's: Evil Twin, Double PhD, and Twin, whereas the longest-established

pond, North Pond, showed a decline that is what might be expected during protracted drought. The overall stability in *T. marcianus* captures/unit effort may reflect an off-setting combination of natural, climatically-driven, decline with explosion of the only viable garter snake species population in the lush, densely-vegetated habitat created in new ponds, which were replete with high densities of fish and larval and juvenile bullfrogs.

As we have previously documented, the checkered garter snake may thrive with bullfrogs, while the Mexican garter snake cannot, by dint of its greater terrestriality, particularly in vulnerable juvenile size-classes (Rosen and Schwalbe, 1998). If these two *Thamnophis* species are in competition, it is clear that such competition would have been strengthened during the drought of the late 1980's through 1998, since checkered garter snakes became much more active in the aquatic habitat occupied by the Mexican garter snake. Similarly, the natural spring-stream-ciénega environment in Black Draw (the former "Río San Bernardino") was occupied almost solely by Mexican garter snakes, until the drought eliminated the central draw spring nursery for the species, leading to dispersal to ponds observed in snakes marked as juveniles. The drought also led to decreased vegetation density in the lower draw ciénega-stream, leading to either emigration or mortality among the resident adult Mexican garter snakes. In the 1990's, this environment was occupied solely by checkered garter snakes. Here, as elsewhere at SBNWR, there were many more checkered garter snakes in Mexican garter snake habitat in the 1990's than in the 1980's.

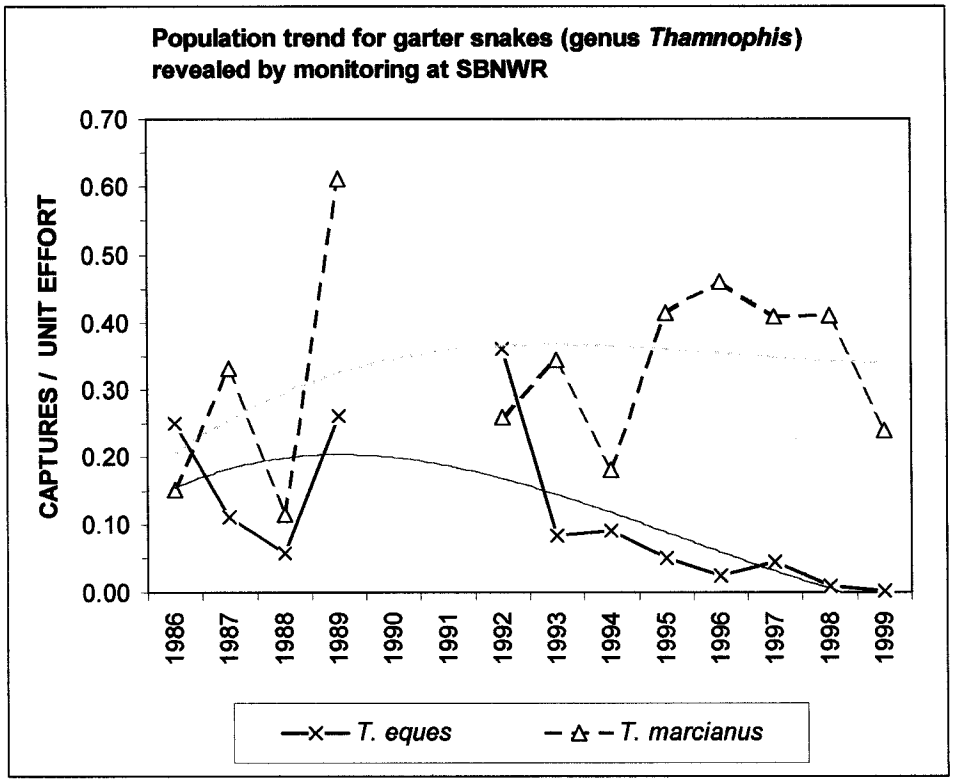

Figure 2. Decline of the Mexican garter snake (*Thamnophis eques*) at San Bernardino NWR, Arizona. Capture effort was computed as the sum of field work days plus aquatic trap-days, as described in text (and see Fig. 1). 3rd-order polynomials are arbitrarily fitted to express general trends obscured by small sample sizes through 1992.

Growth and body condition were good for both species throughout the study, with some variation. Mexican garter snakes grew very rapidly, compared to other localities and to sympatric checkered garter snakes (Rosen and Schwalbe, 1998), suggesting high food availability. However, in both species offspring production averaged less than one litter per year (60% of checkered garter snakes and 50% of Mexican garter snake were gravid in any year (Rosen and Schwalbe, 1988, 1998), although the physiological capability exists for annual reproduction (Rossman et al., 1996; Seigel et al., 2000). Further, in the laboratory Mexican garter snakes must feed regularly and heavily to maintain health and gain weight (unpublished observations), suggesting that this species could be sensitive to lowered resource levels. The Mexican garter snake is more secretive than most semi-aquatic garter snakes (Rosen, 1991), and more shy and nervous in captivity than the checkered garter snake (unpublished observations), and it might be more sensitive reductions in prey density because it may be unwilling to increase its foraging at the expense of exposure to predation risk. If so, the abundance of food for this species at SBNWR might be more apparent than real, and if so, the competitive effect of the checkered garter snake may be contributing to the observed decline of the Mexican garter snake.

An additional possibility is that the interaction of checkered and Mexican garter snakes is mediated through predation, with abundance of the checkered garter snake producing a functional response in shared predators. Given the asymmetry in ability to avoid bullfrog predation, any increase in predation pressure for garter snakes might disproportionately affect the Mexican garter snake. Further, although one is not accustomed to imagining bullfrogs as efficient, responsive, switching predators, their dietary (Bury and Whelan, 1985) and behavioral diversity suggests they may be. Here again, it is not possible to exclude the hypothesis that the presence of the checkered garter snake worsens the bullfrog-induced decline of the Mexican garter snake. One prediction of this hypothesis is that the decline of the Mexican garter snake should be less severe where similar and closely related species like the checkered garter snake (De Queiroz and Lawson, 1994) are absent. The Agua Fria River basin, and especially the Verde River mainstem would be good places to look into this, as would the Canelo Hills, Huachuca Mountains, and San Raphael Valley.

This long discussion of potential interspecific competition in garter snakes (see Reichenbach and Dalrymple, 1980, 1986; Seigel, 1984) should not obscure the probably stronger and more direct effects of bullfrog predation and competition with the Mexican garter snake. The extreme failure of recruitment in the snake cannot be attributed to energetic stress, as reproduction has occurred regularly at SBNWR and juvenile growth and apparent health has been strong, however infrequently observed. Moreover, the bullfrog, with 45% of the adult dietary volume composed of larval and juvenile bullfrogs may a major direct competitor. A more germane question for eventual recovery of the Mexican garter snake, to which we may look forward with considerable far-sightedness, is whether the destruction of leopard frog populations by bullfrogs and other factors produces an irremediable reduction in the snake's food base. Although bullfrog densities are indeed impressive, a large fraction of their biomass exists as adults too large to eat. An equivalent biomass of leopard frogs would have at least an order of magnitude higher food resource density for garter snakes. An absence of ranid frogs or other abundant amphibians as prey – now the norm where bullfrogs are absent – may also have a devastating effect on the Mexican garter snake (as well as most other garter snake species), as discussed below.

II. Population trend and environmental setting, Audubon Research Ranch and vicinity.

Trapping carried out at Finley Tank (above O'Donnell Canyon bottom in the south end of the Sonoita Grasslands) during 1985-1988 was repeated using identical equipment and protocols

during 2000. In addition to scale clipping, the 2000 work included PIT tag implantation. Traps and procedures were as described for the San Bernardino NWR. Details of field schedules, activities, and ecological information are included for this and other sites in Appendix I.

Water level at Finley Tank was up to 1 m lower in 1996 and 2000 than it was during 1985-1988. Pupfish (*Cyprinodon macularius eremus*) remained abundant, but Chiricahua leopard frogs (*Rana chiricahuensis*) declined rapidly from abundance in 1985 and 1986. They were uncommon in 1987, and absent in 1988, and, as far as we know, have not been seen since. As described elsewhere in this report, bullfrogs invaded Babocomari after 1988, and were found at Finley Tank, where they bred successfully despite considerable efforts to eliminate them, in 2000; and a bullfrog also reached as far as Post Canyon Dam Tank in 2000.

Leopard frogs were not seen elsewhere in the Research Ranch vicinity during 1988 (P.C. Rosen, unpublished notes), so their rediscovery by one of us (E. Wallace) in 2000 was most welcome. Although leopard frogs were widespread in the Sonoita Grasslands portion of the Research Ranch and at Elgin in 1985-1986 (Rosen and Schwalbe, 1988), they have not, to our knowledge, reappeared at any sites in those areas. By contrast, the O'Donnell-Post-Freeman-Welch observations for 2000 (Appendix I) rather closely mirror similar observations in 1985-1986 (P. Rosen, field notes). However, at that time, Gila chubs (*Gila intermedia*) were present in Turkey Creek (extirpated during late 1980's drought) and were remarkably abundant in the lower perennial to semi-perennial reaches of O'Donnell Creek, where green sunfish (*Lepomis cyanellus*; present but not very abundant then) now dominate strongly (Appendix I). Other changes may also have occurred: longfin dace (*Agosia chrysogaster*) were seen (locally) in Turkey Creek and Post Canyon in 1985-1988 (P. Rosen, field notes) but not in 2000. The persistence of *R. chiricahuensis* is in a biological environment that has continued to slowly deteriorate, and could become intractable with the appearance of the bullfrog.

It is worth reiterating that the 1985-1988 study was done during the end of a period of high and regular rainfall. Productivity was high, water was plentiful in semi-perennial waters that didn't have fish, and leopard frogs were widely seen in some abundance over much of the area surveyed for *T. eques* in southeastern Arizona (Rosen and Schwalbe, 1988; Schwalbe and Rosen, 1988). The situation was probably better than had been seen by Clarkson and Rorabaugh (1989), who first definitively identified the systematic decline of leopard frogs in the Southwest. However, during the 1960's and 1970's, leopard frogs were far more widespread and abundant in the region (Frost and Platz, 1983; Platz and Frost, 1984, J. Frost, unpublished field notes) than they were during the 1985-1986 garter snake work. The persistence of good conditions for garter snakes in the mid-1980's was thus a local and temporary phenomenon dependant upon a run of favorable weather, 1977-1984 especially.

Therefore, it should come as no surprise that we found widespread evidence of reduction in Mexican garter snake populations in the area since 1985-1988; at the same time, the likelihood that climatic fluctuations will again be favorable may offer but scant hope in face of an overall deterioration of the native aquatic biota that supports *T. eques*. Capture rates for this snake at Finley Tank in 2000 were only 1/6th (16%) of the earlier rate (Table 3), and numerous recaptures that accumulated over the course of the relatively few 2000 captures certify that a major decline had occurred. The closest comparison is for capture rates adults in 2000 versus 1986, and the difference is still highly significant ($\chi^2 = 9.88$, $df = 1$, $p = 0.002$), and thus the decline is obviously statistically significant overall and for both adults and juveniles.

Table 3. Mexican garter snake (*Thamnophis eques*) capture rates using standardized traps at Finley Tank, Audubon Society Research Ranch, Santa Cruz County, Arizona.

		Captures				Captures / Trap-Day:		
YEAR	Trap-Days	Adults	Juveniles	Neonates	Total	Adults	Juveniles	All
1986	43.6	22	43	0	65	0.50	0.99	1.49
1987	52.8	28	39	3	70	0.53	0.80	1.33
1988	27.4	26	15	0	41	0.95	0.55	1.50
2000	105.1	21	3	0	24	0.20	0.03	0.23
All Years	229.0	97	100	3	200	0.424	0.450	0.873

The decline at Finley Tank occurred following the demise of the Chiricahua leopard frog in 1987 there, where the frog had been as abundant or more abundant than anywhere else in the area. The combination of leopard frogs and pupfish offered an excellent combined food source, with stability assured by the pupfish populations, large food items readily available in the form of adult frogs, and, presumably, flushes of food abundance following frog reproduction. In laboratory tests during 2000, Finley Tank pupfish at densities 5 per 7 or 14 gallons of water ate black worms, scuds, commercial fish food, and alfalfa pellets, but not hatchling lowland leopard frogs (*Rana yavapaiensis*; San Pedro River gene pool; E. Wallace, P. Rosen, unpublished data). The density of garter snakes, estimated at 95 individuals (excluding neonates) in about 0.2 ha, makes it evident that they were the primary predator, at least for frogs, and very likely were responsible for the rapid disappearance of the leopard frog at that site.

Although garter snakes were not nearly so abundant elsewhere in the region, a similar process may have been at work: as the environment desiccated naturally after 1985-1986, leopard frogs were forced from briefly-perennial, relatively predator-free waters back into core perennial waters where reproduction was largely unsuccessful as a result of native and introduced predators. The disappearances confirmed in the 1980's in this vicinity were at Finley Tank (with garter snakes), Post Canyon Dam (with a high density population of Sonoran mud turtles *Kinosternon sonoriense*) and tinajas (with largemouth bass *Micropterus salmoides*), and waters that dried (Babocomari "Creek" at Elgin, Teyes Tank, Vaughn Canyon). This is part of a regional decline in the food base of the Mexican garter snake.

The decline of frogs at O'Donnell Creek and Ciénega is less well documented because more intensive observation would be required in such a large, complex, and densely vegetated environment. At O'Donnell, leopard frogs were seen in 1986, but not subsequently, including at low water in the foresummer drought of 1988, when 21 *T. eques* were found gorging themselves on fish trapped in shrinking pools. In 2000, a few *R. chiricahuensis* (including two larvae) were seen in this lower semi-perennial reach, despite the presence of green sunfish and crayfish (*Orconectes virilis*). Ranid frogs may persist for years in the safety of boggy ciénega areas that are tremendously overgrown and lack open waters that support and attract an abundance of predators. Perhaps this is part of why leopard frogs are absent at Turkey Creek – the site had relatively more water supporting abundant predator populations (*T. eques, Gila intermedia*) and less overgrown bog. Furthermore, O'Donnell Creek is near enough to smaller, semi-perennial grassland springs (Welch Spring and Freeman Spring, both in Post Canyon) where there are no non-native species, moderate abundances of mud turtles, and, thus far, no garter snake records. In 1986 *R. chiricahuensis* was present; they were not re-checked until 2000, when reproduction was seen at both grassland springs. Similarly, leopard frogs appeared to totally vanish from the relatively simple habitat at Post Canyon Dam and tinajas by 1987, and probably became

restricted to the grassland springs, re-occupying the lower canyon in wetter times. Thus, metapopulation dynamics were and are possible in the O'Donnell-Post-Welch-Freeman complex, but may not be possible for the more isolated waters of Finley Tank and Turkey Creek. Further investigation of the possibility of essentially indefinite persistence of adult *Rana chiricahuensis* in major ciénegas, as reproductively inactive propagules awaiting high water, would be highly significant for conservation of leopard frogs, and, by extension, garter snakes (note that should bullfrogs enter this environment, they could similarly survive). Similarly, further long-term observations, and new telemetry and reproductive studies of *Rana chiricahuensis* and *Rana yavapaiensis* (and, unfortunately, *Rana catesbeiana*) metapopulation dynamics in O'Donnell and Empire Ciénegas and their streams would provide key information needed for conservation of both native frogs and snakes. There is little doubt that the only available tool for learning how these animals use ciénegas is radiotelemetry.

There is thus some evidence that the demise of leopard frogs may have contributed to the decline of the Mexican garter snakes at Finley Tank and elsewhere. At sites where leopard frogs are absent, often apparently due to introduced centrarchid fish (especially largemouth bass and green sunfish) as at Babocomari, Mexican garter snakes have become rare prior to the arrival of the bullfrog. With only fish to eat, growth is probably markedly reduced, and further, at centrarchid sites there are generally few small-to medium-sized fish, of edible size for most garter snakes. In that scenario, garter snake reproduction is likely to be reduced, and juvenile growth slowed, as is consistent with the low densities and generally smaller snakes seen at Babocomari. At Finley Tank, the abundance of pupfish probably sustained juvenile foraging success, growth, and survivorship, whereas adult females probably had greater difficulty

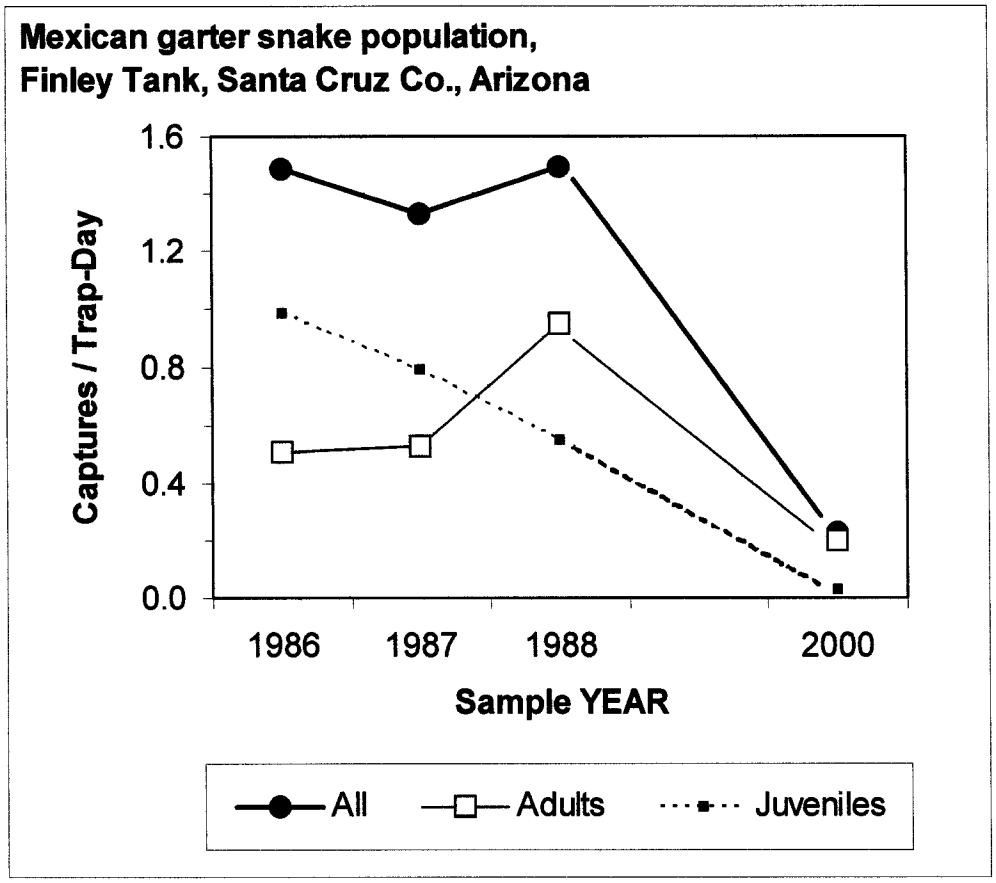

Figure 3. Decline of the Mexican garter snake (*Thamnophis eques*) at Finley Tank.

satisfying energetic requirements for reproduction or rapid growth. This may be responsible for the garter snake decline. Bearing in mind that Mexican garter snake reproduction is significantly influence by energetics during the previous year, this hypothesis is consistent with the marked and steady decrease in recruitment correlated with progressive leopard frog decline from 1985-1987 and the absence of leopard frogs in 2000 (Fig. 3). It is quite possible that leopard frog extinction has caused reduced reproductive output to decline, and that consequently reduced recruitment has driven the observed population decline. This seems to be consistent with abundance patterns observed at other sites where amphibians are rare (Babocomari, O'Donnell, Turkey Creek, Ciénega Creek at Empire Ranch), although we haven't sufficient data conclusively to demonstrate declines there (see below). It surely is not revolutionary thinking to propose that elimination of the bullfrog without restoration of leopard frogs may do little to save the Mexican garter snake.

That said, it is certainly not clear that the Mexican garter snake can persist indefinitely in bullfrog-dominated sites, and there is evidence that it probably cannot (see section on SBNWR, above). Conversely, it is not clear that this snake cannot persist indefinitely – in much-reduced but stable populations – where they are essentially completely dependant on fish and terrestrial vertebrates, and perhaps earthworms (Marcias Garcia and Drummond, 1988). We may have the unfortunate opportunity to see this hypothesis put to test at Empire Ranch and O'Donnell, but with the spread of bullfrogs through the Sonoita Grasslands, even this small favor may not be granted at Finley.

Limited trapping conducted at Turkey Creek in 1985-1988 was moderately successful, while many hand captures were made. In 2000, no snakes and but a single shed was found in five rigorous searches. Mr. Bill Steen, a reliable informant who lives there, reported (in 2000) seeing garter snakes at his goldfish pond. In the 1980's there was a low density of black-necked garter snakes in the Canelo Hills (including at Post Canyon), so the observations available for Turkey Creek in 2000 do not demonstrate persistence of the Mexican garter there, although it is certainly the likely garter snake. As the fish are gone from Turkey Creek, the absence of both leopard frog and canyon treefrog (*Hyla arenicolor*, which was seen in the 1980's) seems puzzling. It would appear that, at a minimum, the abundance of the Mexican garter snake was substantially lower in 2000 than in 1985-1988.

Similar results were obtained at O'Donnell Creek, although prior to the drought observations in 1988 (described above), high vegetation density made it very difficult to find garter snakes. Thus, although none were seen in 2000, nothing conclusive can be said about the population at this site. However, all evidence is consistent in indicating a marked decline of the Mexican garter snake in this region of the Canelo Hills and Sonoita Grasslands.

III. Population trend at Scotia Canyon, Huachuca Mountains.

Peter Holm assisted us with locating and setting traps in Scotia Canyon, to match our 2000 sampling to his 1993 results (Holm and Lowe, 1994). However, he reported the use of longer drift fences than we used (Holm and Lowe, 1994), potentially increasing the expected capture rate. Longer fences in these environments may add little success because (1) movement activity may be concentrated along banks or other narrow corridors that a 3-5 m fence would be placed to intercept, (2) snakes may enter the traps to get at trapped animals, and (3) long fences may not be effectively set in the tight quarters of many Southwestern wetlands. Nonetheless, trapping methods were not identical between these two studies, and sufficient recaptures were not made to permit population estimation. Observed capture rates were lower in 2000 than 1993 (Table 4), especially for neonates (including small juveniles < 300 mm SVL).

Table 4. Mexican garter snake (*Thamnophis eques*) capture rates using aquatic traps at spring-fed ponds in Scotia Canyon, Huachuca Mountains, on the Coronado National Forest, Cochise Cruz County, Arizona.

		Captures			Captures / Trap-Day	
YEAR	Trap-Days	Adults + Juveniles	Neonates	Total	Adults + Juveniles	All
1993	144	10	17	27	0.069	0.188
2000	40	2	1	3	0.050	0.075
All Years	184	12	18	30	0.065	0.163

While there may have been a decline at Scotia Canyon from 1993, our data is not sufficient to demonstrate it. The reduced observations of neonates and small juveniles, while approaching statistical significance, could be a transitory phenomenon or one produced by chance (in the sense that one or two fecund females might be responsible for all of a single year's young; where females are few and reproduction variable in time, the young of the year found may be a pseudo-replicated value in terms of statistical testing).

Peter Holm removed most of the bullfrogs at Scotia Canyon in 1993, finding only one mammal and two bullfrogs in 79 stomachs dissected (Holm and Lowe, 1994). Bullfrog densities were not as high (64 adults at 14.4 kg; plus 98 juveniles at ca. 5.6 kg; totaling 182 frogs at 20.1 kg removed in 2 ponds, plus stream, and associated wetlands) as at SBNWR (e.g., 55 kg removed at a single pond). Holm and Lowe (1994) reported that leopard frogs were rare in Scotia Canyon in 1980-1981, and they reported none for 1982 or 1993. No ranid frogs were seen there in 1985-6 (Rosen and Schwalbe, 1988), and bullfrogs were apparently found in the early stages of expansion in 1989 and had overrun the site by 1992 (Holm and Lowe, 1992). Holm and Lowe noted that the rarity of leopard frogs in 1980-1982 was associated with underweight and starved garter snakes. Their visual encounter rate in 1980-1982 was 0.42 per calendar-day (8 snakes), compared to 0.095 in 1993 (4 snakes). They noted that the snakes were eating tiger salamanders, mountain treefrogs, and, as the predominant diet item in 1993, bullfrogs. In 1993, there appeared to be fewer, much larger garter snakes (Holm and Lowe, 1994), as previously reported for the Mexican garter snake under bullfrog predation (Rosen and Schwalbe, 1988). Their report of apparent starvation and poor body condition associated with decline of the leopard frog population is consistent with the hypothesis (presented above) that reduced food availability may be responsible for the garter snake decline at Finley Tank.

Perhaps the leopard frogs at Scotia died from disease, or suffered a local extinction from garter snake predation, but as far as we know there are not sufficient observational data or field notes available to evaluate these hypotheses. What is known is that tiger salamanders (*Ambystoma tigrinum*, presumably . *A. t. stebbinsi*) and mountain treefrogs (*Hyla wrightorum*) have been found at this site through the past two decades and probably for much longer. Fish have not been reported. Hylid frogs, as well as the abundant lizard life around the ponds (*Sceloporus scalaris, S. jarrovii*, and to a lesser extent *S. clarkii, Holbrookia maculata, Cnemidophorus "sonorae"*, and *Elgaria kingii*) would sustain garter snakes in the absence of leopard frogs, and tiger salamander larvae (which are relished by Mexican garter snakes is captivity) would provide a major addition to the diet, possibly sustaining the snake population at a level that could drive the leopard frog population to extinction. The collapse of leopard frog populations all across the west side of the Huachucas, which may be ascribable to non-native species from the introduction site at Parker Canyon Lake, could have prevented recolonization of

Scotia Canyon by leopard frogs, even before bullfrogs made that moot.

All that can be stated about the Mexican garter snake at Scotia is that our evidence suggests a possible decline from 1980-1982, to low capture rates in 1993, and to even lower ones in 2000. However, the data are too sparse to support any firm conclusion beyond establishing that the snake definitely persists there. The set of ecological conditions confronting the snake here, and the great biodiversity of this region, suggest that Scotia Canyon and Bear Creek would be important sites for monitoring focused on key species populations and interacting biota. It would be of interest to study the ecological segregation of Mexican and black-necked garter snakes here, as this northwest quadrant of the Huachuca Mountains supports the only Madrean populations of the Mexican garter snake in the U.S.A., elsewhere only the black-necked garter snake is the species found in Madrean montane waters.

IV. Other sites where trapping was conducted.

Lower San Raphael Valley

Significant trapping was also done in the lower San Raphael Valley, at Santa Cruz River mainstem, Sharp Spring, and Heron Spring. No snakes were trapped, but five garter snakes were seen (and all three captured were *T. eques*, as expected in that region) in work spanning six days (see Appendix I). This is the only site, other than the intensive study sites, where more than a single Mexican garter snake was found. Four of the observations were along the mainstem, and the fifth was at Sheehy Spring. A 6th observation was reported during summer 2000 by Jim Rorabaugh and Ross Humphreys at Sheehy Spring on Humphreys' cattle ranch. Thus, there is clearly a significant population persisting over an extensive habitat area in the lower San Raphael Valley, probably a trans-national one. Trapping returns, however, suggest that population density is low.

There is some other general information about the ecosystem of that area. Bullfrogs have invaded all perennial waters in the region, and E. Wallace found them more or less abundant, or at least prominent, throughout. They were absent or rare in the early 1980's at Sharp (1983-1985), Sheehy (1983), and Heron (1983) Springs (P. Rosen, field notes), and not very common on the Santa Cruz. In 2000, bullfrog larvae were observed in the Santa Cruz. Both native and introduced fishes are present, Sonoran mud turtles are in the river and all springs, and A. Stefferud reported a lowland leopard frog in the river near the border in 2001 (J. Rorabaugh, pers. comm., 2001). Perhaps conditions were good for this frog in Mexico in 2001, as 3 individuals were also seen, and one collected, by SBNWR Refuge Manager Bill Radke, at Snail Spring (near House Pond at Slaughter Ranch), near the border in Cochise County in 2001; a lowland leopard frog tadpole was seen in Guadalupe Canyon in 1998, as well (J. Rorabaugh, personal communication, 2001).

There is a new Arizona state park adjoining the border along the Santa Cruz River in this area, with vegetation density increasing under protection from grazing. Although bullfrogs may always be feeding into the river from lentic habitats around it, their abundance in the river may be proximately controlled by their reproductive success in it and by flooding, at least where there are no artificial ponds nearby. This appears to be a good area where monitoring can aimed at exploring the dynamics of bullfrogs under moderate flood scour, the recovery of vegetation after cessation of grazing, and the effects of these factors on native fishes and Mexican garter snakes. The accessability, size, and relatively tractable vegetation structure of this area make it a suitable site for study of the Mexican garter snake using telemetry. Furthermore, a marking study to determine population size may be feasible at or near the state park.

This population was not well-known prior to 2000. In 1984, T. Jones reported a Mexican garter snake at Sharp Spring, and occasional records have been reported, including one in the late 1990's (P. Holm, personal communication), at the main lower road crossing (Lochiel) of the river. There are no reports of a dense or abundant population. The 2000 observations demonstrate that this population is persisting, and suggest that it may not be declining, or at least not rapidly.

Arivaca Ciénega

This is a historic locality for both the Mexican garter snake and Chiricahua leopard frog (Rosen and Schwalbe, 1988), neither of which appear to have been recorded there since at least 1980. Extensive snake trapping carried out in the ciénega in 1994 and 2000 yielded a total of 3 checkered garter snakes (1994, plus a fourth captured by hand) and a single Mexican garter snake (2000), along with a single road-killed black-necked garter snake. With a total of 84 trap-days at the site (Appendix I), the capture rate was 0.048 captures per trap day for all *Thamnophis*, clearly indicating rarity at the site. The combination of excessive grazing through the mid-1980's with a massive bullfrog population (present at least as early as 1985; Rosen and Schwalbe, 1988) probably strongly suppressed the snake populations. The persistence of bullfrogs and other harmful non-native species (Appendix I) probably will prevent recovery of garter snakes or leopard frogs at the site, at least as long as artificially maintained open water is present and bullfrogs are breeding in stock ponds on surrounding terrain.

Nonetheless, the capture of a single *T. eques* at Arivaca Ciénega in 2000 is an encouraging indication of the tenacity of a species that long ago apparently became rare in the area. An alternative interpretation is that more extensive survey is needed, in the slightly drier ciénega flats upstream of the core area, and along the stream below the Ruby Road crossing, where a shed skin of a probable *T. eques* was found in 1986 (Rosen and Schwalbe, 1988). Neither area has been fully adequately investigated, given the now-confirmed persistence. The bullfrog problem at Arivaca is one of the most difficult in the region. Although this species could technically be controlled in the many stock ponds in the area that support large populations, there is an apparent unwillingness to cooperate among at least some of the private property owners. Even if such control was established, Arivaca Lake, which may support a limited number of adult bullfrogs but a massive number of metamorphs that can disperse toward the ciénega, is likely to remain as it is for some time. Even when and if the lake is removed, bullfrogs could not, under tried methods, be removed from the ponds that are being maintained in the ciénega. Arivaca Ciénega would be an interesting place to study the effect of removing only the artificial pond habitat within the ciénega proper on the populations of the bullfrog and the species it negatively affects.

Babocomari Ciénega

In the 1980's survey, four Mexican garter snakes were seen and captured at Babocomari Ciénega with substantial effort. It was apparent that the species was rare, as great efforts were made throughout what was then presumed to be optimal habitat. This presumption is verified by early observations that *Thamnophis eques* was found extremely abundant at Babocomari Ranch pond on June 5, 1958 (R. Bezy, personal communication, 2002), where we found none despite intensive efforts. The reason or set of reasons for the early decline cannot be determined now by us, as limited data is at hand concerning the ecosystem, but it is to be presumed that competition, and possibly predation, by non-native fishes at the site was involved. As noted by John Frost during the height of his intensive leopard frog surveys in the mid-1970's, "It probably at one time supported a tremendous sympatric population of lowland and southern form [i.e., Chiricahua] leopard frogs. However, introduction of bass has changed the picture ... 3 or 4 frogs in a walk of

about 1.5-2 miles along the river at various points. Simply too many introduced fish" (J. Frost, unpublished field notes for 29 February 1976). We still lack direct evidence of abundance of leopard frogs at Babocomari, and evidence that they declined when the fish were introduced or became widespread, both significant facts given the complexity and size of the habitat area. The big impoundment at Babocomari Ranch was the center for exotic predatory fish abundance at Babocomari in the mid-1980's, so the questions relevant to the history and potential future of this site are numerous.

Despite unanswered questions, the findings at Babocomari support observations at Finley Tank and Scotia Canyon that identify leopard frog decline as a significant impact on the decline of the Mexican garter snake. The most likely scenario is that introduced fish that led to the disappearance of leopard frogs and great reductions in the native fish assemblage (which would have been less predator-dominated and hence would have had higher densities of small-to-medium-size fish). This would have led to reduced growth and reproduction in the Mexican garter snake It is further possible that large predatory fish were eating the snakes (W. Minckley, personal communication, 1986). Although trapping and hand-capture were attempted in 2000, no garter snakes were found. Presumably some few still exist, but with the additional insult of bullfrog invasion after 1986, or more probably after 1989 (P. Rosen, field notes; they were very abundant by 2000), this garter snake population will likely continue to decline.

In 1986, at high water, Mexican garter snakes and Chiricahua leopard frogs were fairly abundant in the Babocomari Creek at Elgin town, where it was a large, semi-perennial, open ciénega stream. Also, a possible *T. eques X T. marcianus* hybrid was found ½ way between Sonoita and Elgin. This area has been much drier after 1986, and probably does not support many, if any, of these species today. When wet conditions return for some years, it may be worthwhile to return to Elgin for additional survey. Other than that, the only evident reason for further study of the Mexican garter snake at Babocomari would be to investigate the possibility that the addition of bullfrogs to a site where introduced fish have already decimated the garter snake population might turn out to be slightly beneficial. This is possible if adult bullfrog numbers are regulated by the exotic fish, while larval and juvenile bullfrogs add to the food base. It may not be likely, but it is possible.

V. Other surveyed sites.

Ciénega Creek at Empire-Ciénega Ranch

This site is the best, most natural ciénega remaining in southern Arizona, and it supports a large and dense population of the Gila topminnow, numbering one or more million individuals. In deeper waters of the mainstem are large, robust populations of the Gila chub, and longfin dace are abundant in shallower, more rocky and sandy (less ciénega-like) sections. There are no non-native fishes in the natural habitat, and very few stock ponds in the region. Lowland and Chiricahua leopard frogs were both abundant at one time, and there was contact without evidence of hybridization between them. Lowland leopard frogs were very abundant near Ciénega Ranch – the region of the main road crossing, which was the focus of early surveys – with Chiricahua leopard frogs found as one walked upstream (south), as well as in abundance at several accessible stock ponds in the headwaters region (J. Frost, unpublished field notes for 8 March 1975, ca. 14 March 1975, 16 May 1975, 29 February 1976, and many others). The habitat is densely and beautifully vegetated, and Mexican garter snakes were readily collected in it near the Mattie Canyon confluence, at a place referred nowadays as "Shangri La" (see Appendix I).

Trapping has not been carried out at this locality, and would be difficult with the protocol

at hand because the steep, undercut banks and deep water render trap placement difficult. Net-mesh traps will need to be designed and built for effective sampling in this environment. Other than at lower San Raphael Valley, this is the only site where a Mexican garter snake was captured by hand in 2000, although individuals presumed to be this species were seen at Scotia Canyon, Finley Tank, and Turkey Creek (Appendix I). Further, a bullfrog collected from the stream source pool in 1996 had eaten one, and they were occasionally observed during intensive native fish study there (J. Simms, personal communication, 1996; see further information in Appendix I). However, Dennis Caldwell (personal communications, 1999-2001), a competent observer of aquatic herpetofauna, has carried out extensive survey work and bullfrog removals at this locality during 1998-2001 and has not observed any garter snakes. This suggests that the scarcity of leopard frogs that has become conspicuous after the mid-1980's through mid-1990's (see Appendix I) may be causing a decline of the Mexican garter snake at this site. The available data, though limited, do point toward decline here, although the only definite conclusion we can make is that the species is persisting.

Lower Ciénega Creek at Ciénega Creek County Preserve

The place called Pantano ("Marsh Station" along the Southern Pacific Railroad line) can be imagined, according to its name, in pre-incision times. By the early 1980's the site was deeply incised within naked adobe walls to a depth of over 5 m, and with heavy grazing the stream was a sandy, scantily-vegetated run with insufficient cover for a strong Mexican garter snake population. It was visited a number of times during 1986-1990 Rosen and Schwalbe, 1988; P. Rosen, unpublished), often to wash up after field trips to other wetlands in southeastern Arizona (!) The only garter snake seen was a black-necked garter snake. Lowland leopard frogs were always found, and in summer were abundant, as they remained, in late summers, until 2001 (Rosen and Schwalbe, 2002, *this report*). The area was purchased by Pima County as a natural preserve, with grazing eliminated, leading to increasing development of ciénega vegetation and evolution of deep scour pools after 1995 (D. Caldwell, J. Fonseca, personal communications, 1999-2001). A Mexican garter snake was first reported and photographed from the site in 1998 and the species has been observed occasionally at the site since then (D. Caldwell, personal communications). It appears likely that the species has actually increased at this site, based both on the reported observations and on an expectation based on improvement of the habitat. In 2000, scouring floods removed vegetation and sanded in pools, changes whose temporal persistence and effects remain to be seen.

The evidence that this site has supported an increase in the Mexican garter snake, and its connection to the key upstream environment, make Ciénega Creek as a whole the highest priority place for monitoring the Mexican garter snake and important interacting species (ranid frogs, fishes, other garter snakes, riparian lizards, and predators, including other snakes). Ciénega Creek appears to have the highest potential of any site in the U.S.A. for preservation of the Mexican garter snake.

Lewis Springs and San Pedro River at Highway 90

This site has been investigated a number of times since 1986, with a single 1996 report (reportedly supported by photo voucher) of the Mexican garter snake in the Heritage Database. Additional survey would be useful, as the area is large and complex, and garter snake population density is likely to be low. Furthermore, with protection of the San Pedro River from grazing under auspices of Bureau of Land Management, dense streamside vegetation has developed, enhancing the habitat quality of the environment for garter snakes. Bullfrog abundance in the river is moderate, and may not, by itself, prevent persistence or recovery of the snake. However,

the river is dominated by non-native predatory fishes (largemouth bass, green sunfish, black bullheads, mosquitofish, and reportedly [Mark Fredlake, personal communication] flathead catfish [*Pilodictis olivaris*]), crayfish, and spiny softshell turtles (*Apalone spinifera*). There is thus a reduced food base for a highly aquatic garter snake, and the checkered garter snake, a species that might naturally be found primarily "in muddy puddles a mile or so from the river" (Van Denburgh, 1922), is likely to be at an advantage, and to continue an apparent increase from early times when the Mexican garter snake predominated on this river (Van Denburgh, 1922). Lewis Springs has been invaded by crayfish, green sunfish, and bullfrogs, and it is not clear that any of its formerly prominent native aquatic vertebrates (longfin dace, lowland leopard frog, Sonoran mud turtle, Mexican garter snake; Rosen and Schwalbe, 1988; see Appendix I here) can thrive or persist there.

Sites Re-visited Once

Bog Hole was an outstanding locality for the Mexican garter snake in 1986 (Rosen and Schwalbe, 1988), and one where snakes may be readily seen if they are present. Re-visited in 2000, it was found to have more bullfrogs, no pupfish, and no sightings of garter snakes. Ponds at Barchas Ranch, Huachuca Mountain bajada, were surveyed in 2000 to follow up on the 1996 observation by E. Wallace (listed in Heritage Database), but no snakes were seen. Upper 13 Reservoir, a tank on the Patagonia Mountain bajada at which the snake was reliably reported in 1984, yielded no observations in 2000. Similarly, a brief visit to the windmill pond between Elgin and Sonoita, where fairly extensive recreational cover turning in the 1980's yielded the putative hybrid garter snake, also failed to yield a snake record. These are additional data points, and do not exclude the possibility that the snakes persists at these localities. Aside from Bog Hole, single visits to such sites would be expected to have had a low likelihood of encounter with the Mexican garter snake regardless of whether it had declined or not.

Summary of Site Descriptions

At the most intensively studied site, San Bernardino NWR, there was clear and definite evidence of a systematic decline of the Mexican garter snake to or near extinction by 1999. At the second intensively studied site, Finley Tank at Audubon Research Ranch, there was significant evidence in 2000 of a post 1988 decline that was probably systematic but may also reflect an unfavorable phase of in the natural climatic fluctuation. At a third study site, Scotia Canyon in the Huachuca Mountains, capture rates were lower in 2000 than in 1993, but not significantly so. Among remaining sites, favorable results were obtained at 3 and unfavorable results at 11. The most encouraging result was an apparent increase at Ciénega Creek County Preserve, along with persistence at Empire Ranch (despite the negative result of low observation rate there). An extensive, it not abundant population was also documented at and near the Santa Cruz River near the Mexican border in San Raphael Valley, although no evidence is available on population trend at this site. The third piece of good news is rediscovery of the Mexican garter snake at Arivaca Ciénega in 2000, although the species is clearly rare there. On balance, since the last survey in 1985-1988, increases are suggested at 1 site, some measure of stability was suggested for 2 sites, negative trends or findings were registered for 14 sites, and large, statistically significant declines were demonstrated for 2 sites. Positive findings: 1. Indication of possible stability: 2. Negative findings: 14. Major demonstrated declines: 2. Documented population extinctions: 0. The result is one of widespread decline, with little to mitigate a prospect of impending disaster; the only auspicious finding is that decline is often slow, and the species tenacious, in good habitat, allowing time for action if action is initiated.

Systematic causes of decline have been identified, at least in the form of well-supported

hypotheses, that are at work on the Mexican garter snake in southern Arizona. A most disturbing finding in this study is the continued march of the hypothesized agents causing decline affecting it and its staple prey, lowland and Chiricahua leopard frogs: non-native predatory and competing species. The bullfrog, green sunfish, and virile crayfish, three very damaging species have spread to and/or increased in abundance in presently or formerly occupied Mexican garter snake localities. The dispersal of the bullfrog into the Sonoita Grasslands and to the threshold of the Canelo Hills is the most disheartening advance, but the spread of crayfish into Lewis Springs is similarly unfortunate. These last two species are likely to prove difficult to get rid of once they invade natural perennial waters suitable for the Mexican garter snake, and there has been no successful management of any of these species in the habitat of this snake in southern Arizona. Almost equally disturbing is the systematic, well documented decline of the staple prey, and the evidence that such decline may well have a major systematic effect on the Mexican garter snake.

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RECOMMENDATIONS

The known strongholds of the Mexican garter snake in the United States were identified in southeastern Arizona in 1985-1988. By then, this species had already long-since disappeared from the Colorado and Gila Rivers, the Salt River gallery forest and its environs at Phoenix, key known populations on the Santa Cruz River, Rillito, and elsewhere in the Tucson basin, much of the Santa Cruz and San Pedro Valleys in the United States. Camp Verde and the Sonoita Grassland-Canelo Hills-San Raphael Valley were the only two areas known with substantial populations. Camp Verde has not been re-surveyed, a task somewhat complicated by the rapid urbanization of the Verde Valley – that broad rich basin central to the largely canyon-bound river. In this report, the decline of the Mexican garter snake in its core distribution in southern Arizona has been clearly documented. Although no absolute local extinctions since 1988 have been proven, this may reflect a prolongation of decline by long adult life and by the difficulty of proving extinction in an animal that is fairly challenging to find even when it is abundant. The causes of its decline are profound, and cannot even be adequately investigated at the level of interest generated thus far. Furthermore, its decline is intimately linked to two other profound declines: the quality of lowland perennial waters in the American Southwest, and the collapse of it prey base, native fishes and native ranid frogs. For these reasons, a leading recommendation can appropriately request that:

1. The Mexican garter snake in the United States (*Thamnophis eques megalops*) should be petitioned to be listed as a Threatened Species.

2. Surveys should be initiated in Mexico to provide a view of its persistence in various regions of its distribution there.

3. The Verde River and Sub-Mogollon population areas in Arizona should be re-surveyed.

4. Active steps to protect remaining natural habitats of the Mexican garter snake and its primary prey, the Chiricahua leopard frog (*Rana chiricahuensis*) and lowland leopard frog (*Rana yavapaiensis*), should be taken in southern Arizona:

    a. The only known way to halt the spread of the bullfrog (*Rana catesbeiana*) is to prevent its occupation of artificial habitat in areas intervening between areas it has occupied and those where it is not yet established. Perennial stock ponds and golf course ponds are key stepping stones for bullfrog dispersal now, whereas larger fishing lakes are merely reservoirs of bullfrogs where surrounding waters may already be saturated with bullfrogs. Stock ponds and golf course ponds should be treated aggressively to eliminate their status as non-native species refugia and population centers.

    b. Laws and rules should be made to:

        i. discourage and prohibit the creation and maintenance of habitat for harmful non-native species that obviously facilitates the spread of such species into sensitive habitat, and,

        ii. encourage the integration of important aquatic species conservation measures into core economic activities in the Southwest.

    c. Research into means of controlling and eliminating harmful non-native species

should be supported by funding, including for basic ecological research on such species in Arizona, and chemical, mechanical, and biological control methods.

d. Effects and potential usefulness of various levels of grazing in wetland areas should be scientifically investigated rather than merely argued and posited, with a focus on effects on fish, frogs, and garter snakes.

e. Managed waters in urban areas should be actively investigated as locations where lowland aquatic species may be restored and managed, and where control over water supplies may be adequate to meet the challenge of introduced species.

5. Ecological research on key areas of the basic biology of sensitive species should be supported, in order to promote an understanding that may be adequate to devise and test solutions for the varied problems confronting rare, endangered, threatened, sensitive, and declining aquatic species:

a. The Mexican garter snake should be studied to determine:

i. Its behavioral utilization of ciénega habitat,
ii. Effects of prey type and abundance on fecundity,
iii. Diseases and parasites that may affect it,
iv. Population density and function at low density population sites,
v. Behavioral and other contrasts in and out of sympatry with *T. marcianus*,
vi. Its ability, and that of its primary prey, to persist in pure natural habitat of various types despite the presence of non-native species

B. Native leopard frogs should be studied to determine:

i. Metapopulation functions (dispersal, reproduction, long-term survival) in areas with complex natural wetlands and peripheral sites,
ii. Drought behavior and tolerance,
iii. Local adaptation to ecological conditions such as variable seasonal optima for breeding,
iv. Habitat characteristics under which they outperform bullfrogs (e.g., Sartorius and Rosen, 2000),
v. The interactions between them and natives fishes,
vi. Factors which may promote or resist disease.

6. Ecological monitoring focused on sensitive species, but with a clear vision of the various indicators and elements of ecosystem function, is a powerful way to maintain a record and develop an understanding of events that are (or will later be) relevant for conservation biology. While ecosystems are, indeed, complex, the forces at work in them are strong: they seem intolerably subtle primarily because we fail to observe or record in even an elementary way. Ecological monitoring, in rocket-science striving, can price itself out of existence quite easily. It is absolutely critical that careful records be kept on what was done and observed. However, formalized protocols are best when large funds are available for targeted sites. Except then, and in some cases even then, monitoring with an awareness of ecosystem dynamics (rather than using a statistically detached approach) will yield the most relevant knowledge. Major natural wetlands are sufficiently unique, and contain so many diverse micro-environments, that a flexible approach to monitoring should prevail until locally-established protocols can be worked out, tested, and

synthesized with others to strengthen or enhance compatibility and comparison of results.

The following recommendations are made according to this prescription, although funds should be sought to develop more firmly quantitative and directly repeatable formal protocols at key sites, and whenever feasible. The monitoring proposed here may be met by one or more productive and well-timed visits to sites per year. A requirement is that they be done and recorded or synthesized by an outfit under contract or by agencies with flexible, regular, and timely database storage operations for results and annotated observations. In either case, maintaining the integrity of the data must be a high priority:

a. Ciénega Creek is a key locus for monitoring of diverse native (and in the case of the bullfrog, exotic) ranid frogs, fishes, turtles, and garter snakes. There are two sections with divergent ecologies, the Empire-Ciénega headwaters basin and the downstream Pantano semi-desert ciénega stream. A third environment may be identified in the peripheral fish-free pools and pans (e.g., Cinco Ponds) in the flats of the uppermost basin. There are several key dynamics for which observations would be most useful:

   i. Population trends overall, body size, and habitat specificity of occurrence in the Mexican garter snake (a telemetry study may be appropriate here),
   ii. Habitat-specific reproductive success and changing abundance of the bullfrog (any bullfrog and exotic fish populations outside the natural waters should be identified and, if possible, eliminated),
   iii. Population dynamics and abundance of the Chiricahua leopard frog in the upper basin and the lowland leopard frog in the lower basin (additional research may be focused here in tandem with monitoring).
   iv. Trapping methods suitable for quantitative monitoring of garter snakes in ciénega and stream environments should be developed.

b. O'Donnell Ciénega and surrounding waters are a key area to investigate interactions between leopard frog metapopulation dynamics, non-native species (invading bullfrogs, established crayfish, and green sunfish that may be successfully removed), and populations of the Mexican garter snake:

   i. Occurrence and reproductive success of Chiricahua leopard frogs at several local sites (telemetry studies of individuals would be useful here),
   ii. The progression of bullfrog populations should be closely observed, even as attempts to halt it a strategic choke points should be made (Post Canyon Dam Pond, where an exploding bullfrog population derived from Babocomari, Finley, or as yet unidentified sources can be predicted; this pond is close enough to give the bullfrogs access to O'Donnell Ciénega, from which they might become impossible to remove: the only effective bullfrog predator at O'Donnell, the green sunfish, is subject to removal to benefit the Gila chub. A solution would be to breach the Post Canyon Dam and restore a tinaja-based ecosystem there: the turtles might best be translocated),
   iii. The persistence of the Mexican garter snake in this and surrounding areas should be monitored. Re-censussing at Finley Tank can be accomplished periodically at small expense.

c. The lower San Raphael Valley should be monitored, including the Santa Cruz

River, and any of the following for which regular observations can be made: Sharp, Sheehy, and Heron Springs, and tanks proximal to the river. The following objectives may be pertinent:

i. The abundance and reproductive success of bullfrogs in the river and other habitats should be observed,
ii. The site should be monitored to look for successful invasion or persistence by the lowland leopard frog, or the presence of the Chiricahua leopard frog,
iii. The full extent and abundance of the Mexican garter snake in the area needs to be determined during the monitoring, and perhaps assisted by some intensive sampling of a repeatable kind, such as trapping.
iv. Monitoring may be designed to examine the same parameters on grazed and un-grazed areas to provide direct observation of potentially positive or negative effects of grazing.

d. Scotia Canyon should be monitored to record ongoing fluctuations that may occur among the several species of interest: Mexican garter snake, bullfrog, tiger salamander, mountain treefrog, and other anurans, as well as to observe various other animals characteristic of Madrean woodland.

7. The following sites are most in need of re-survey for presence absence and general abundance of the Mexican garter snake: Bog Hole, Lewis Springs and adjoining San Pedro River, Arivaca Creek.

8. Successful captive breeding needs to be demonstrated in this species.

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APPENDIX I. TABULAR DATA ON LEOPARD FROG DISEASE IN SOUTHERN ARIZONA

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Site	Subsite	date	YR	Observers	Start	Stop	SP	#obs live	#obs dead	#pos chyt	#neg chyt	tot Frog	VDL ref #	Diagnosis Notes
AEPCO		13-Jan-00	2000	Enderson	11:49	13:17	RABL	2	0	1	0	2	00-0154	dermatitis, hyperplastic, chronic, diffuse, modrate, with hyperkeratosis and sporangia of chytrid fungi
Aliso		9-Jun-98	1998	Caldwell			RAYA	4	0			4	Field-23	
Aliso		2-Aug-98	1998	Caldwell			RAYA	1	0			1	Field-25	
Aliso		20-Nov-99	1999	Titcomb	10:00	10:45	HYAR	1	0			1	Field-47	
Aliso		20-Nov-99	1999	Titcomb	10:00	10:45	RAYA	8	0			8	Field-48	
Aliso		4-Dec-99	1999	Titcomb	11:00	12:07	HYAR	2	0			2	Field-57	
Aliso		4-Dec-99	1999	Titcomb	11:00	12:07	RAYA	8	1			9	Field-58	
Aliso		8-Jan-00	2000	Titcomb	13:20	14:40	RAYA	2	0			2	Field-66	
Aliso		5-Feb-00	2000	Titcomb	13:45	15:00	RAYA	11	0			11	Field-88	
Aliso		13-Nov-00	2000	Titcomb	11:00	12:10	RAYA	0	0			0	Field-129	
Aliso		26-Nov-00	2000	Titcomb	10:45	11:45	RAYA	6	0			6	Field-140	
Aliso		6-Dec-00	2000	Caldwell, Field	12:30	14:30	RAYA	2	0			2	Field-149	
Aliso		16-Dec-00	2000	Titcomb	14:55	15:25	HYAR	1	0			1	Field-156	
Aliso		16-Dec-00	2000	Titcomb	14:55	15:25	RAYA	4	0			4	Field-157	
Aliso		21-Jan-01	2001	Titcomb	14:29	15:25	RAYA	5	0			5	Field-164	
Aliso		11-Feb-01	2001	Titcomb, Caldwell, Fellows	13:00	15:30	RAYA	9 (+)	0			9	Field-168	

Site	Subsite	date	YR	Observers	Start	Stop	SP	#obs live	#obs dead	#pos chyt	#neg chyt	tot Frog	VDL ref #	Diagnosis Notes
Aliso	trail cross to sycamore with branch bent low over stream	6-Nov-01	2001	Caldwell, Field	10:48	12:15	RAYA	19	0			19	Field-187	
BANWR	Noviyo tank	10-May-00	2000	Surhe			RACA	0	1	0	1	1	00-1446	Submucosal edema with focal endothelial necrosis, fibrin deposition and heterophilic inflammation, submucosa, stomach; ascites
Big Spring		19-Dec-92	1992	Sredl			RAYA	0	55			55	Field-1	
Big Spring		23-Dec-92	1992	Seim			RAYA	55	55	3	0	110	92-4345	chytrid fungi were observed
Big Spring		26-Dec-92	1992	Sredl								0	Field-2	
Big Spring		2-Jan-93	1993	Sredl								0	Field-3	
Big Spring		12-Jan-94	1994	Sredl								0	Field-4	
Big Spring		5-Feb-00	2000	Sredl, Field								0	Field-87	
Buehman		27-Aug-98	1998	Enderson			RAYA		2	0	2	2	98-3542	dermatitis, verminous, granulomatous, multifocal, mild to moderate, skin
Buehman		20-Feb-99	1999	Enderson			RAYA	0	4	1	0	4	99-0533	dermatitis, hyperplastic, chronic, diffuse, severe, with intracorneal sporangia of chytrid fungi; cutaneous acariasis
Buehman		18-Nov-99	1999	Enderson	13:30	16:36	RAYA	100	0			100	Field-45	

Site	Subsite	date	YR	Observers	Start	Stop	SP	#obs live	#obs dead	#pos chyt	#neg chyt	tot Frog	VDL ref #	Diagnosis Notes
Buehman		15-Dec-99	1999	Enderson	11:46	15:27	RAYA	8	5	4	0	13	99-3644	all four frogs were diagnosed as follows; dermatitis, hyperplastic, subacute, diffuse, severe, with hyperkeratosis and intracorneal of chytrid fungal sporagia; plus dermal granulomas with mites, multifocal, skin
Buehman		11-Jan-00	2000	Enderson	14:33	15:57	RAYA	2	2	1	0	4	00-0124	dermatitis, hyperplastic, chronic, diffuse, moderate, with sporangia of chytrid fungi; endoparasitism+AB126
Buehman	"Middle Buehman"	2-Feb-00	2000	Enderson	13:15	16:52	RAYA	2	0			2	Field-86	
Buehman	From start of Nature Conservancy property, downstream ca. 1 mile to second (of two) corral– "Middle Buehman Canyon"	2-Nov-00	2000	Enderson, Bezy	14:00	16:33	RAYA	64	0			64	Field-127	
Buehman	ca. 2 miles upstream from the Bullock Canyon jct to Nat. Forest boundary – "Upper Buehman Canyon"	15-Nov-00	2000	Enderson	11:36	14:50	RAYA	8	0	?	?	8	00-4487	Chytridiomycosis, trematodiasis multifocal lung, trematodiasis multifocal skin+AA13

Site	Subsite	date	YR	Observers	Start	Stop	SP	#obs live	#obs dead	#pos chyt	#neg chyt	tot Frog	VDL ref #	Diagnosis Notes
Buehman	ca. 1.5 miles downstream from second corral– "Lower Buehman Canyon"	5-Dec-00	2000	Enderson, Bezy	12:57	15:00	RAYA	43	19	4	0	62	00-4818	dermatitis, hyperplastic, diffuse, severe, with hyperkeratosis and sporangia of chytrid fungi, for frogs EE-BC-12-05-02,03,05,07
Buehman	ca. 1.5 miles downstream from second corral– "Lower Buehman Canyon"	16-Oct-01	2001	Sredl	14:30	17:00	RAYA	2000	0			2000	Field-179	
Cent. AZ	Sierra Estrella	10-Dec-92	1992	Waters, Sredl			RABE	0	100			100	GCU	
Cent. AZ	Barnhardt Mesa	25-Apr-95	1995	Sredl				55	25			80	GCU	
Cent. AZ	Blue River	6-Nov-97	1997	Miera, Healy			RACH	0	0			0	97-5051	
Cent. AZ	Cottonwood Cr	12/00/1998	1998				none	0	0	6		0	98-4619	
Cent. AZ	Rock Cr., Mesquito Wash	20-Jan-99	1999	Sredl, Miera			RAYA	0	0	13		0	99-0220	
Cent. AZ	Rock Cr	19-Nov-99	1999	Sredl	14:25	15:25	none	0	0			0	Field-46	
Cent. AZ	Crouch Cr.	5/00/1999	1999	Healy, Sredl			RACH	0		0		0	99-1583	
Cent. AZ	Rock Cr., Mesquito Wash	9/00/1999	1999	Sredl			none	0	0	0		0	99-2724	
Cent. AZ	Bonita Cr.	19-Jan-00	2000	Enderson	14:12	14:52	none	0	0			0	Field-72	
Cent. AZ	Agua Fria	30-Jan-00	2000	Sredl	12:00	12:45	RAYA	1	0			1	Field-84	
Cien_Emp	Empire Gultch	8-Sep-97	1997	Caldwell			RACA	7	0			7	Field-22	
Cien_Emp	Empire Ranch perserve	28-Jun-98	1998	Caldwell			RACA	1	0			1	Field-24	
Cien_Emp	Empire Ranch picnic area	22-Mar-99	1999	Repp			RACH	4	0			4	Field-30	

Site	Subsite	date	YR	Observers	Start	Stop	SP	#obs live	#obs dead	#pos chyt	#neg chyt	tot Frog	VDL ref #	Diagnosis Notes
Cien_Emp	Spring at Empire Gultch	22-Mar-99	1999	Repp			RACH	4	0			4	Field-31	
Cien_Emp	Empire Gultch Spring	19-Apr-99	1999	Caldwell			RACH	3	0			3	Field-34	
Cien_Emp	Main Cienega	19-Apr-99	1999	Caldwell			RACA	5	0			5	Field-35	
Cien_Emp	Empire Ranch picnic area	3-May-99	1999	Caldwell			RACH	1	0			1	Field-37	
Cien_Emp	Empire Ranch picnic area	14-Nov-99	1999	Caldwell, Wolner	12:00	14:00	RACA	11	0			11	Field-43	
Cien_Emp		14-Nov-99	1999	Caldwell, Wolner			RACH	11	0			11	Field-44	
Cien_Emp	Empire Ranch picnic area	29-Nov-99	1999	Caldwell, Wolner	10:00	11:00	RACH	8	0			8	Field-52	
Cien_Emp		12-Dec-99	1999	Caldwell, Wolner	12:00	13:00	RACH	4	0			4	Field-59	
Cien_Emp	Empire Ranch picnic area	16-Jan-00	2000	Caldwell, Wolner	13:00	15:00	none	0	0			0	Field-69	
Cien_Emp		16-Jan-00	2000	Caldwell, Wolner	12:00	13:00	RACH	3	0			3	Field-70	
Cien_Emp_rdc	Road CYN Tank	16-Jan-00	2000	Caldwell, Wolner	15:00	16:00	RACH	4	0			4	Field-71	
Cien_Emp		17-Feb-00	2000	Caldwell, Wolner			RACA	5	0			5	Field-92	
Cien_Emp	Empire Ranch picnic area	21-Feb-00	2000	Caldwell, Wolner	12:00	14:00	none	0	0			0	Field-95	
Cien_Emp		21-Feb-00	2000	Caldwell, Wolner	11:00	12:00	RACH	5	0			5	Field-98	
Cien_Emp	Springwater Cyn of Cienega creek	15-Jul-00	2000	Caldwell			RACA	4	0			4	Field-114	
Cien_Emp	Cienega Creek	3-Dec-00	2000	Caldwell, Wolner	11:00	15:00	none	0	0			0	Field-144	
Cien_Emp	Empire Gulch Spring	3-Dec-00	2000	Caldwell, Wolner	10:00	10:30	RACA	2	0			2	Field-145	

Site	Subsite	date	YR	Observers	Start	Stop	SP	#obs live	#obs dead	#pos chyt	#neg chyt	tot Frog	VDL ref #	Diagnosis Notes
Cien Cr (Co)			1998				RAYA	0	2	0	2	2	98-0531	dermatitis, proliferative, multifocal, severe, with intraepidermal organisms suggestive of protozoa; endoparasitism, multifocal, submucosa, serosa and mesentery of stomach and small intestine
Cien Cr (Co)		24-Jan-99	1999				RAYA	2	0	1	0	2	99-0243	dermatitis, hyperplastic, subacute, diffuse, modrate, with hyperkeratosis and intracorneal sporangia of chytrid fungi
Cien Cr (Co)	Empire Ranch	28-Mar-99	1999	Caldwell			RACA	1	0			1	Field-32	
Cien Cr (Co)	Empire Ranch	28-Mar-99	1999	Caldwell			RAYA	1	0			1	Field-33	
Cien Cr (Co)	Gardner Cyn confluences	3-May-99	1999	Caldwell			RACA	6	0			6	Field-36	
Cien Cr (Co)	From clay mine down until water went underground	19-Jun-99	1999	Caldwell			RAYA	1	0			1	Field-38	
Cien Cr (Co)	from Horse shoe bend in RR track to about Three bridges	23-Aug-99	1999	Caldwell			RAYA	55	0			55	Field-40	
Cien Cr (Co)	from Horse shoe bend in RR track to about Three bridges	23-Aug-99	1999	Caldwell			RACA	5	0			5	Field-39	
Cien Cr (Co)	at dam 1 mile east of Colossal Cave Rd.	7-Sep-99	1999	Carter, Pruss			RACA	6	1			7	Field-41	
Cien Cr (Co)		27-Sep-99	1999	Caldwell			RACA	100	0			100	Field-42	

Site	Subsite	date	YR	Observers	Start	Stop	SP	#obs live	#obs dead	#pos chyt	#neg chyt	tot Frog	VDL ref #	Diagnosis Notes
Cien Cr (Co)			1998				RAYA	0	2	0	2	2	98-0531	dermatitis, proliferative, multifocal, severe, with intraepidermal organisms suggestive of protozoa; endoparasitism, multifocal, submucosa, serosa and mesentery of stomach and small intestine
Cien Cr (Co)		24-Jan-99	1999				RAYA	2	0	1	0	2	99-0243	dermatitis, hyperplastic, subacute, diffuse, modrate, with hyperkeratosis and intracorneal sporangia of chytrid fungi
Cien Cr (Co)	Empire Ranch	28-Mar-99	1999	Caldwell			RACA	1	0			1	Field-32	
Cien Cr (Co)	Empire Ranch	28-Mar-99	1999	Caldwell			RAYA	1	0			1	Field-33	
Cien Cr (Co)	Gardner Cyn confluences	3-May-99	1999	Caldwell			RACA	6	0			6	Field-36	
Cien Cr (Co)	From clay mine down until water went underground	19-Jun-99	1999	Caldwell			RAYA	1	0			1	Field-38	
Cien Cr (Co)	from Horse shoe bend in RR track to about Three bridges	23-Aug-99	1999	Caldwell			RAYA	55	0			55	Field-40	
Cien Cr (Co)	from Horse shoe bend in RR track to about Three bridges	23-Aug-99	1999	Caldwell			RACA	5	0			5	Field-39	
Cien Cr (Co)	at dam 1 mile east of Colossal Cave Rd.	7-Sep-99	1999	Carter, Pruss			RACA	6	1			7	Field-41	
Cien Cr (Co)		27-Sep-99	1999	Caldwell			RACA	100	0			100	Field-42	

Site	Subsite	date	YR	Observers	Start	Stop	SP	#obs live	#obs dead	#pos chyt	#neg chyt	tot Frog	VDL ref #	Diagnosis Notes
Cien Cr (Co)		13-Nov-99	1999	Caldwell, Wolner, Sredl	12:00	15:30	RAYA	30	0	1	0	30	99-3322	dermatitis, hyperplastic, chronic, diffuse, modrate, with hyperkeratosis, mild, and, intracorneal fungal organisms; spherical structures compatible with sporangia of chytrid fungi
Cien Cr (Co)		21-Nov-99	1999	Caldwell, Wolner	12:00	15:00	RAYA	16	0			16	Field-49	
Cien Cr (Co)		22-Nov-99	1999	Caldwell, Wolner	12:00	14:30	RAYA	30	0			30	Field-50	
Cien Cr (Co)		27-Nov-99	1999	Caldwell, Wolner	11:30	14:00	RAYA	19	0			19	Field-51	
Cien Cr (Co)		3-Dec-99	1999	Caldwell								0	Field-56	
Cien Cr (Co)		12-Dec-99	1999	Caldwell, Wolner	14:00	16:00	RAYA	6	3	2	0	9	99-3585	dermatitis, hyperplastic, diffuse, severe, with hyperkeratosis and chytrid fungi
Cien Cr (Co)		22-Jan-00	2000	Caldwell, Wolner	12:00	16:00	RAYA	10	2			12	GCS	
Cien Cr (Co)		6-Feb-00	2000	Caldwell, Wolner	12:30	16:00	RAYA	8	4			12	GCS	
Cien Cr (Co)		13-Feb-00	2000	Caldwell, Wolner	12:30	16:00	RAYA	2	2			4	GCS	
Cien_David son		13-Feb-00	2000	Caldwell, Wolner	11:00	12:30	RAYA	2	1			3	Field-90	
Cien_David son		21-Feb-00	2000	Caldwell, Wolner	12:00	12:30	RAYA	2	0			2	Field-96	
Cien_David son		21-Feb-00	2000	Caldwell, Wolner	14:00	14:30	RAYA	4	0			4	Field-97	
Cien Cr (Co)		27-Feb-00	2000	Caldwell, Wolner			RAYA	5	5			10	Field-99	

Site	Subsite	date	YR	Observers	Start	Stop	SP	#obs live	#obs dead	#pos chyt	#neg chyt	tot Frog	VDL ref #	Diagnosis Notes
Cien_Davidson		27-Feb-00	2000	Caldwell, Wolner			RAYA	5	5	1	0	10	00-0621	dermatitis, hyperplastic, subacute, diffuse, severe, with hyperkeratosis and sporangia of chytrid fungi
Cien Cr (Co)		4-Mar-00	2000	Caldwell, Wolner	12:30	16:00	RACA	2	0	0	1	2	00-0698	no pathologic diagnosis
Cien Cr (Co)		4-Mar-00	2000	Caldwell, Wolner	12:30	16:00	RAYA	3	1			4	Field-100	
Cien_Davidson		4-Mar-00	2000	Caldwell, Wolner	12:00	12:30	RAYA	1	0			1	Field-101	
Cien_Davidson		4-Mar-00	2000	Caldwell, Wolner	16:30	17:30	RAYA	3	0			3	Field-102	
Cien Cr (Co)		19-Mar-00	2000	Caldwell, Wolner	14:00	15:00	HYAR	1	0			1	Field-103	
Cien Cr (Co)		19-Mar-00	2000	Caldwell, Wolner	14:00	15:00	RACA	1	0			1	Field-104	
Cien Cr (Co)		19-Mar-00	2000	Caldwell, Wolner	14:00	15:00	RAYA	1	0			1	Field-105	
Cien_Davidson		19-Mar-00	2000	Caldwell, Wolner	13:30	14:00	RAYA	2	0			2	Field-106	
Cien_Davidson		19-Mar-00	2000	Caldwell, Wolner	11:00	13:00	RAYA	2	0			2	Field-107	
Cien Cr (Co)		23-Mar-00	2000	Caldwell			RACA	1	0	0	1	1	00-0951	no chytrid fungi
Cien_Davidson		23-Mar-00	2000	Caldwell, Wolner			RACA	1	0	0	1	1	00-0951	no chytrid fungi
Cien_Davidson		23-Mar-00	2000	Caldwell, Wolner	12:00	12:30	RAYA	4	0			4	Field-108	
Cien Cr (Co)		4-Jun-00	2000	Caldwell			RAYA	2	0			2	Field-109	
Cien Cr (Co)		4-Jun-00	2000	Caldwell			RACA	3	0			3	Field-110	

Site	Subsite	date	YR	Observers	Start	Stop	SP	#obs live	#obs dead	#pos chyt	#neg chyt	tot Frog	VDL ref #	Diagnosis Notes
Cien Cr (Co)		10-Jun-00	2000	Fonseca			RAYA	4	0			4	Field-111	
Cien Cr (Co)	Aqua Verde and Cienega Creek	13-Jun-00	2000	Fonseca, Schorr, Bill			RACA	5	0			5	Field-112	
Cien Cr (Co)	Cienega Well	13-Jun-00	2000	Fonseca, Schorr, Bill			RAYA	4	0			4	Field-113	
Cien Cr (Co)		28-Jul-00	2000	Lawson			RAYA	55	0			55	Field-115	
Cien Cr (Co)	From clay mine 3/4 mile down to end of perennial flow.	7-Oct-00	2000	Caldwell, Wolner			RACA	1	0			1	Field-117	
Cien Cr (Co)	From clay mine 3/4 mile down to end of perennial flow.	7-Oct-00	2000	Caldwell, Wolner			RAYA	149	0			149	Field-118	
Cien Cr (Co)	30 yards upstream and downstream from confluence of Davison Cyn.	7-Oct-00	2000	Caldwell, Wolner			RACA	3	0			3	Field-116	
Cien_David son	25m perennial flow in Davidson and pools at confluence with Cienega.	7-Oct-00	2000	Caldwell, Wolner			RACA	3	0			3	Field-119	
Cien_David son	25m perennial flow in Davidson and pools at confluence with Cienega.	7-Oct-00	2000	Caldwell, Wolner			RAYA	4	0			4	Field-120	
Cien Cr (Co)	From clay mine 3/4 mile down to end of perennial flow.	14-Oct-00	2000	Caldwell, Wolner			RAYA	74	0			74	Field-121	
Cien Cr (Co)	From clay mine 3/4 mile down to end of perennial flow.	14-Oct-00	2000	Caldwell, Wolner			RACA	3	0			3	Field-122	

Site	Subsite	date	YR	Observers	Start	Stop	SP	#obs live	#obs dead	#pos chyt	#neg chyt	tot Frog	VDL ref #	Diagnosis Notes
Cien_David son	25m perennial flow in Davidson near confluence with Cienega.	14-Oct-00	2000	Caldwell, Wolner			RAYA	7	0			7	Field-123	
Cien Cr (Co)	From clay mine 1/2 mile down to tidbit site.	29-Oct-00	2000	Caldwell, Wolner	16:00	18:30	RAYA	1	0			1	Field-124	
Cien Cr (Co)	From clay mine 3/4 mile down to end of perennial flow.	12-Nov-00	2000	Caldwell, Wolner	10:30	13:00	RAYA	1	0			1	Field-128	
Cien Cr (Co)	From clay mine 3/4 mile down to end of perennial flow.	19-Nov-00	2000	Caldwell, Wolner	12:00	14:00	RAYA	2	1			3	Field-134	
Cien Cr (Co)	25m perennial flow in Davidson and pools at confluence with Cienega and 1/2 mile of Cienega creek from Davidson to Three Bridges.	19-Nov-00	2000	Caldwell, Wolner	10:30	12:00	none	0	0			0	Field-135	
Cien_David son	25m perennial flow in Davidson and pools at confluence with Cienega and 1/2 mile of Cienega creek from Davidson to Three Bridges.	19-Nov-00	2000	Caldwell, Wolner	10:30	12:00	none	0	0			0	Field-136	
Cien Cr (Co)	From clay mine 3/4 mile down to end of perennial flow.	26-Nov-00	2000	Caldwell, Wolner	12:00	14:00	RAYA	1	2			3	Field-141	
Cien Cr (Co)		3-Dec-00	2000	Caldwell, Wolner	13:30	16:00	HYAR	1	0			1	Field-147	

Site	Subsite	date	YR	Observers	Start	Stop	SP	#obs live	#obs dead	#pos chyt	#neg chyt	tot Frog	VDL ref #	Diagnosis Notes
Cien Cr (Co)		3-Dec-00	2000	Caldwell, Wolner	13:30	16:00	RAYA	4	0			4	Field-148	
Cien Cr (Co)	From clay mine 3/4 mile down to end of perennial flow.	9-Dec-00	2000	Caldwell, Wolner	12:30	15:30	RAYA	0	1			1	Field-151	
Cien_David son	S. of I-10	9-Dec-00	2000	Caldwell, Wolner	10:30	12:00	RAYA	1	0			1	Field-152	
Cien Cr (Co)	From clay mine 3/4 mile down to end of perennial flow.	14-Jan-01	2001	Caldwell, Wolner	13:00	15:30	none	0	0			0	Field-163	
Cien Cr (Co)	From clay mine 3/4 mile down to end of perennial flow.	4-Feb-01	2001	Caldwell, Wolner	12:00	14:30	RAYA	5	1			6	Field-167	
Cien Cr (Co)	From clay mine 3/4 mile down to end of perennial flow.	1-Apr-01	2001	Caldwell, Wolner	12:00	14:30	RACA	1	0			1	Field-170	
Cien Cr (Co)	From clay mine 3/4 mile down to end of perennial flow.	10-Jun-01	2001	Caldwell, Wolner	8:30	10:30	RACA	2	0			2	Field-171	
Cien_David son	S. of I-10	10-Jun-01	2001	Caldwell, Wolner	7:00	8:00	none	0	0			0	Field-172	
Cien Cr (Co)	From clay mine 3/4 mile down to end of perennial flow.	2-Sep-01	2001	Caldwell, Wolner	12:00	15:00	RACA	1	0			1	Field-173	
Cien Cr (Co)	From clay mine 3/4 mile down to end of perennial flow.	2-Sep-01	2001	Caldwell, Wolner	12:00	15:00	RAYA	1	0			1	Field-174	
Cien Cr (Co)	Clay mine area.	3-Sep-01	2001	Caldwell	20:00	22:00	RACA	6	0			6	Field-175	
Cien Cr (Co)	From Pantano to clay mine 3.25.	8-Sep-01	2001	Caldwell, Wolner	7:00	12:00	RAYA	12	0			12	Field-176	
Cien_David son	S. of I-10	10-Sep-01	2001	Caldwell	10:00	12:00	RAYA	1	0			1	Field-177	

Site	Subsite	date	YR	Observers	Start	Stop	SP	#obs live	#obs dead	#pos chyt	#neg chyt	tot Frog	VDL ref #	Diagnosis Notes
San Pedro R.	Mammoth, Dudleyville	14-Aug-95	1995	Nelson, Sartorius			RAYA	5	0			5	Field-11	
San Pedro R.	Lower to upper	19-Aug-95	1995	Nelson	10:30	12:25	BUWO	1	0			1	Field-13	
San Pedro R.	Lower to upper	19-Aug-95	1995	Nelson	10:30	12:25	RAYA	4	0			4	Field-14	
San Pedro R.	.5 mi N. River Rd., Sam Manuel	31-Dec-95	1995	PCR, Nelson			RAYA	1	0			1	Field-15	
San Pedro R.	Arivipa Rd.	31-Dec-95	1995	PCR, Nelson			RAYA	1				1	Field-16	
S. Pedro Basin	Bass Cyn.	22-Nov-99	1999	Wallace	14:00	17:00	RAYA	5	1	1	0	1	99-3726	dermatitis, hyperplastic, subacute, diffuse, moderate,sporangia of chytrid fungi
San Pedro R.		9-Jan-00	2000	Caldwell, Wolner			RAYA	5	5	3	0	10	00-0085	dermatitis, hyperplastic, chronic active, diffuse, moderate to severe, with hyperkeratosis and sporangia of chytrid fungi; saprolegniasis
San Pedro R.		11-Jan-00	2000	Enderson			none	0	0			0	Field-67	
S. Pedro Basin	Tar Wash Tank	23-Jan-00	2000	Fonseca, Windes, Wallace			RAYA	10	0			10	Field-78	
S. Pedro Basin	Tucson Wash Tank	23-Jan-00	2000	Fonseca, Windes, Wallace			RA	0	0			0	Field-79	
San Pedro R.	Bingham	23-Jan-00	2000	Fonseca, Wallace			RAsp	1	0			1	Field-76	
San Pedro R.	Bingham	23-Jan-00	2000	Fonseca, Wallace			RACA	1	0			1	Field-77	

Site	Subsite	date	YR	Observers	Start	Stop	SP	#obs live	#obs dead	#pos chyt	#neg chyt	tot Frog	VDL ref #	Diagnosis Notes
San Pedro R.	Bingham	16-Feb-00	2000	Fonseca, Wallace			RAYA	3	0			3	Field-91	
S. Pedro Basin	Paige Cr.	3/00/2000	2000	Wallace			RAYA	1	0	0	0	1	00-0950	diffuse autolysis and much of the epidermis was missing
San Pedro R.	Dudleyvill	3/00/2000	2000	Wallace			RAYA	3	0	3	0	3	00-0950	hyperplastic, AB7hyperkeratosis and sporangia of chytrid fungi
San Pedro R.	Dudleyvill	3/00/2000	2000	Wallace			RACA	1	0	0	1	1	00-0950	no chytrid fungi present
S. Pedro Basin	Aravaipa Creek	4/00/2000	2000	Wallace			RAYA	2	0	1	1	2	00-0950	hyperplastic, hyperkeratosis and sporangia of chytrid fungi
San Pedro R.	St. David	8-Aug-95	1995	Nelson	17:00	17:30	RACA	7	0			7	Field-8	
San Pedro R.	St. David	8-Aug-95	1995	Nelson	17:45	21:22	RACA	55	0			55	Field-9	
SBNWR	Ranarium	26-Oct-97	1997	PCR			RACH	0	2			2	97-4963	
SBNWR	Ranarium	19-Nov-97	1997	Hale			RACH	0	1	1	0	1	98-4358	dermatitis, with hyperkeratosis and intraepithelial chytrid fungi
SBNWR	Leslie Cr.	7/00/1998	1999				RACH	1	0	0	1	1	98-3105	four cytologic smears; no chitrid fungi
SBNWR	Oasis-Twin	9/00/1999	1999	PCR			RACA	0	6	1	5	6	99-2765	tadpole 1 positive for chytrids; all others negative for chytrids
SBNWR	Douglas H. S.		2000	PCR			RACH	0	1	0	1	1	00-0170	mycotic heptatitis and nephritis, multifocal to confluent, with pigmented fungal hyphae
SBNWR	Douglas H. S.		2000	C. Harris			RACH	0	10	0	8	10	00-1690	no lesions of chitridomycosis or chytrid organisms

Site	Subsite	date	YR	Observers	Start	Stop	SP	#obs live	#obs dead	#pos chyt	#neg chyt	tot Frog	VDL ref #	Diagnosis Notes
SBNWR	Bathhouse	winter	2000	PCR			RACA	0	1	0	1	1	00-0170	healthy
SBNWR	Bunting Spring	winter	2000	PCR			RACA	0	4	2		4	00-0170	dermatitis, hyperplastic, subacute, diffuse, moderate, with hyperkeratosis and sporangia of chytrid fungi for 2000.2; dermatitis, hyperplastic, subacute, diffuse, mild, with hyperkeratosis and sporangia of chytrid fungi 2000.6
SBNWR	Leslie (HQ Ranarium)	winter	2000	PCR			RACH	0	2	1	0	2	00-0170	
Syc Cyn		26-Dec-99	1999	Caldwell, Wolner	12:00	16:00	RACH	5	1	1	0	6	00-0011	dermatitis, hyperplastic, subacute, diffuse, severe, with hyperkeratosis and sporangia of chytrid fungi; dermal granuloma, focal, skin of ventrum; saprolegniasis
Syc Cyn		26-Dec-99	1999	Caldwell, Wolner	12:00	16:00	HYAR	1	1			2	Field-62	
Syc Cyn		15-Jan-00	2000	Caldwell, Wolner	12:30	16:00	RACH	9	7	1	1	16	00-0160	dermatitis, hyperplastic, subacute, diffuse, moderate, with hyperkeratosis and sporangia of chytrid fungi for DC-SC-1-15-4; interdermal mites with granulomatous inflammation, skin, DC-SC-1-15-3&4

Site	Subsite	date	YR	Observers	Start	Stop	SP	#obs live	#obs dead	#pos chyt	#neg chyt	tot Frog	VDL ref #	Diagnosis Notes
Syc Cyn		15-Jan-00	2000	Caldwell, Wolner	12:30	16:00	HYAR	2	2	0	3	4	00-0160	interdermal mites with granulomatous inflammation, skin, DC-SC-1-15-8,9,10
Syc Cyn		30-Jan-00	2000	Wallace			RACH	0	2			2	Field-85	
Syc Cyn	From parking area down stream to finger rock, Yank tank, and first side Cyn downstream from parking area.	16-Dec-00	2000	Caldwell, Wolner	14:00	16:30	RACH	0	1			1	Field-154	
Syc Cyn	From parking area down stream to finger rock, Yank tank, and first side Cyn downstream from parking area.	16-Dec-00	2000	Caldwell, Wolner	14:00	16:30	RACH	5				5	Field-155	
Tuc Agua Cal	Tuc_Agua Caliente Cyn.	9-Feb-00	2000	Wallace			HYAR	5	0			5	Field-89	
Tuc Montrose		5-Jan-99	1999	Enderson			RAYA	55				55	Field-26	
Tuc Montrose		7-Jan-99	1999	Sredl, Swann, Enderson			RAYA	0	110			110	Field-27	
Tuc Montrose		7-Jan-99	1999	Sredl, Swann, Enderson			HYAR	1	1			2	Field-28	
Tuc Montrose		18-Jan-99	1999	Sredl, Swann			RAYA	0	0			0	Field-29	

Site	Subsite	date	YR	Observers	Start	Stop	SP	#obs live	#obs dead	#pos chyt	#neg chyt	tot Frog	VDL ref #	Diagnosis Notes
Tuc Montrose		28-Nov-99	1999	Caldwell, Wolner, Swann	11:30	14:45	RAYA	37	1	3	0	38	99-3396	dermatitis, chronic, with epidermal hyperplastia, hyperkeratosis with sporangia of chytrid fungi for A, B, C; granulomas, dermal, multifocal, for A, B, C
Tuc Montrose		28-Nov-99	1999	Caldwell, Wolner, Swann	11:30	14:45	HYAR	25	0	0	1	25	99-3396	granulomas, dermal, multifocal D
Tuc Montrose		15-Dec-99	1999	Swann	14:35	15:44	RAYA	0	17			17	Field-61	
Tuc Montrose		9/00/1999	1999				RAYA	0	5	2		5	99-2655	
Tuc Montrose		9/00/1999	1999				HYAR	0	1			1	Field-192	
Tuc Montrose		20-Feb-00	2000	Wallace, Rourke	14:00	16:15	HYAR	1	0			1	Field-93	
Tuc Montrose		20-Feb-00	2000	Wallace, Rourke	14:00	16:15	RAYA	3	3			6	Field-94	
Tuc Montrose	Trail drop-in to pool 16	2-Nov-00	2000	Hall, Wallace	14:50	17:30	HYAR	1	0			1	Field-125	
Tuc Montrose	Trail drop-in to pool 16	2-Nov-00	2000	Hall, Wallace	14:50	17:30	RAYA	5	0			5	Field-126	
Tuc Montrose	from trail/stream junction to large waterfall pool	21-Nov-00	2000	Sredl, Field	13:40	15:11	none	0	0			0	Field-137	
Tuc Montrose	Trail drop-in to pool 16	2-Dec-00	2000	Hall, Wallace	13:00	15:00	RAYA	2	2			4	Field-143	

Site	Subsite	date	YR	Observers	Start	Stop	SP	#obs live	#obs dead	#pos chyt	#neg chyt	tot Frog	VDL ref #	Diagnosis Notes
Tuc Montrose		28-Nov-99	1999	Caldwell, Wolner, Swann	11:30	14:45	RAYA	37	1	3	0	38	99-3396	dermatitis, chronic, with epidermal hyperplastia, hyperkeratosis with sporangia of chytrid fungi for A, B, C; granulomas, dermal, multifocal, for A, B, C
Tuc Montrose		28-Nov-99	1999	Caldwell, Wolner, Swann	11:30	14:45	HYAR	25	0	0	1	25	99-3396	granulomas, dermal, multifocal D
Tuc Montrose		15-Dec-99	1999	Swann	14:35	15:44	RAYA	0	17			17	Field-61	
Tuc Montrose		9/00/1999	1999				RAYA	0	5	2		5	99-2655	
Tuc Montrose		9/00/1999	1999				HYAR	0	1			1	Field-192	
Tuc Montrose		20-Feb-00	2000	Wallace, Rourke	14:00	16:15	HYAR	1	0			1	Field-93	
Tuc Montrose		20-Feb-00	2000	Wallace, Rourke	14:00	16:15	RAYA	3	3			6	Field-94	
Tuc Montrose	Trail drop-in to pool 16	2-Nov-00	2000	Hall, Wallace	14:50	17:30	HYAR	1	0			1	Field-125	
Tuc Montrose	Trail drop-in to pool 16	2-Nov-00	2000	Hall, Wallace	14:50	17:30	RAYA	5	0			5	Field-126	
Tuc Montrose	from trail/stream junction to large waterfall pool	21-Nov-00	2000	Sredl, Field	13:40	15:11	none	0	0			0	Field-137	
Tuc Montrose	Trail drop-in to pool 16	2-Dec-00	2000	Hall, Wallace	13:00	15:00	RAYA	2	2			4	Field-143	

Site	Subsite	date	YR	Observers	Start	Stop	SP	#obs live	#obs dead	#pos chyt	#neg chyt	tot Frog	VDL ref #	Diagnosis Notes
Tuc Montrose	from pool by trail junction to above waterfall at pool with grey and white swirled boulder	13-Dec-00	2000	Blomquist, Field	12:38	14:46	none	0	0			0	Field-153	
Tuc Montrose	Trail drop-in to pool 16	21-Dec-00	2000	Hall, Wallace	9:25	11:09	HYAR	0	1			1	Field-158	
Tuc Montrose	Trail drop-in to pool 16	21-Dec-00	2000	Hall, Wallace	9:25	11:09	RAYA	0	5			5	Field-159	
Tuc Montrose	from trail/stream junction to large waterfall pool	28-Oct-01	2001	Sredl et al	10:15	15:15	RAYA	6	0			6	Field-182	
Tuc Montrose	from trail/stream junction to large waterfall pool	28-Oct-01	2001	Sredl et al	10:15	15:15	HYAR	18	0			18	Field-183	
Tuc SAGU	Chimenea Cyn.	18-Feb-96	1996	Holm, Wirt, Turner	17:05	17:25	RAYA	6	0			6	Field-17	
Tuc SAGU1		30-Nov-99	1999	Swann	10:00	13:00	HYAR	3	0			3	Field-53	
Tuc SAGU1		30-Nov-99	1999	Swann	10:00	13:00	RAYA	31	0			31	Field-54	
Tuc SAGU2		2-Dec-99	1999	Swann	12:00	13:00	RAYA	47	1	0	0	48	99-3475	frog badly autolyzed; no epidermis present on the skim sections with which to evaluate the presence or abscess of chytrid fungi
Tuc SAGU2		2-Dec-99	1999	Swann	12:00	13:00	HYAR	50	0			50	Field-55	
Tuc SAGU1		14-Dec-99	1999	Swann	11:30	12:30	HYAR	1	0			1	Field-60	
Tuc SAGU2		29-Dec-99	1999	Swann	9:00	10:00	RAYA	35	0			35	Field-64	

Site	Subsite	date	YR	Observers	Start	Stop	SP	#obs live	#obs dead	#pos chyt	#neg chyt	tot Frog	VDL ref #	Diagnosis Notes
Tuc SAGU7a		29-Dec-99	1999	Mike Ward			RAYA	7	0			7	Field-65	
Tuc SAGU1		15-Jan-00	2000	Swann	12:00	13:30	RAYA	2	0			2	Field-68	
Tuc SAGU2		20-Jan-00	2000	Wallace, Swann, Goldberg	10:30	13:30	RAYA	62	2			64	Field-73	
Tuc SAGU8		21-Jan-00	2000	Swann	12:10	13:30	BUPU	0	1			1	Field-74	
Tuc SAGU8		21-Jan-00	2000	Swann			RAYA	5	0			5	Field-75	
Tuc SAGU2		23-Jan-00	2000	Swann	16:00	17:00	HYAR	1	0			1	Field-80	
Tuc SAGU2		23-Jan-00	2000	Swann	16:00	17:00	RAYA	64	0			64	Field-81	
Tuc SAGU4		25-Jan-00	2000	Goldberg, Landon			HYAR	5	0			5	Field-83	
Tuc SAGU4		25-Jan-00	2000	Goldberg, Landon	10:40	12:07	HYAR	2	0			2	Field-82	
Tuc SAGU1	SNP-01	14-Nov-00	2000	Swann	12:00	15:00	RAYA	0	0			0	Field-130	
Tuc SAGU4a	SNP-4a	17-Nov-00	2000	Mike Ward			RAYA	0	0			0	Field-131	
Tuc SAGU4b	SNP-4b	18-Nov-00	2000	Goldberg			RAYA	0	0			0	Field-133	
Tuc SAGU4b	4b	18-Nov-00	2000	Goldberg	12:25	13:50	none	0	0			0	Field-132	
Tuc SAGU4b	SNP-4b	25-Nov-00	2000	Mike Ward			RAYA	0	0			0	Field-138	
Tuc SAGU8	SNP-08	25-Nov-00	2000	Mike Ward	14:30	15:30	RAYA	0	0			0	Field-139	
Tuc SAGU1	SNP-01	1-Dec-00	2000	Mike Ward			RAYA	0	0			0	Field-142	

Site	Subsite	date	YR	Observers	Start	Stop	SP	#obs live	#obs dead	#pos chyt	#neg chyt	tot Frog	VDL ref #	Diagnosis Notes
Tuc SAGU2	SNP-02	2-Dec-00	2000	Mike Ward	13:00	14:00	RAYA	1	2	2	0	3	00-4782	both frog dermatitis, hyperplastic, with hyperkeratosis and sporangia of chytrid fungi
Tuc SAGU8	8	9-Dec-00	2000	Goldberg	12:05	14:00	none	0	0			0	Field-150	
Tuc SAGU4a	Eastern Unit-Lower Wildhorse "SAGU 4A"	24-Dec-00	2000	Moorbeck	12:30	15:00	HYAR	1	0			1	Field-161	
Tuc SAGU8	East Unit-Steel Tank/Rock Springs "SAGU 8"	28-Dec-00	2000	Moorbeck	13:15	15:30	none	0	0			0	Field-162	
Tuc SAGU4b	SAGU 4B	21-Jan-01	2001	Moorbeck	11:30	14:30	none	0	0			0	Field-165	
Tuc SAGU1	1	2-Feb-01	2001	Goldberg	12:30	15:50	none	0	0			0	Field-166	
Tuc SAGU4b	4b	25-Mar-01	2001	Goldberg	9:45	11:00	HYAR	2				2	Field-169	
Tuc SAGU4b	SAGU 4B	4-Nov-01	2001	Moorbeck	13:50	16:30	RAYA	9				9	Field-185	
Tuc SAGU4b	SAGU 4B	4-Nov-01	2001	Moorbeck	13:50	16:30	HYAR	15				15	Field-186	
Tuc SAGU8	SAGU 8	12-Nov-01	2001	Moorbeck	12:53	14:20	HYAR	1				1	Field-188	
Tuc SAGU8	SAGU 8	12-Nov-01	2001	Moorbeck	12:53	14:20	RAYA	5				5	Field-189	
Tuc Tanq V. Wash	Reddington Pass	8-Jan-00	2000				HYAR	0	3	1	1	3	00-0084	saprolegniasis, dermatitis, hyperplastic, with hyperkeratosis and sporangia of chytrid fungi for DC-TC-1-8-2; dermal granulomas with mites (DC-TC-1-8-1, DC-TC-1-8-2)

Site	Subsite	date	YR	Observers	Start	Stop	SP	#obs live	#obs dead	#pos chyt	#neg chyt	tot Frog	VDL ref #	Diagnosis Notes
Tuc Tanq V. Wash	Reddington Pass	8-Jan-00	2000				RAYA	0	2	1	0	2	00-0084	saprolegniasis, dermatitis, hyperplastic, with hyperkeratosis and sporangia of chytrid fungi for DC-TC-1-8-3; dermal granulomas with mites (DC-TC-1-8-3)
Tuc VentCyn	Catalina Mt. Below falls	23-Dec-00	2000	Caldwell, Wolner	12:30	16:00	none	0	0			0	Field-160	

APPENDIX II. COCHISE COUNTY LEOPARD FROG MONITORING SUMMARY

Monitoring summary tables for leopard frogs at the San Bernardino / Leslie Canyon National Wildlife Refuges and surrounding areas

Appendix. Monitoring data for San Bernardino NWR-area leopard frog populations, through 2001.

Table A.1. Monitoring results for the Chiricahua leopard frog at Leslie Creek in Leslie Canyon, Cochise Co., Arizona, 1985-2001.

Date	Time	Primary Observer(s)	Leopard frogs observed	Result (if any)	Survey method / extent	Other aquatic ecosystem observations
1974-5						
5-Dec	afternoon	John Frost	20-25 all sizes; tads additional	22.5	"kicked in"; warm day good activity	*chiricahuensis*, 1 *blairi* observed
1-Feb	1000-1200	John Frost	50 (all sizes, no tads seen)	46	thorough search	"90-95%" *chiricahuensis*; large ones seen.
19-May	1900-2100	John Frost	100 or so frogs + 1 clutch	100	thorough search	1 *blairi*; good *R. chir* calling; cool, 35mph wind.
1986:						
23-Jul	0900-1200	PR	v. abund., incl. huge frogs	75	Visual, splash; entire reach	Some bullfrog-sized ones seen (1 collected)
1993:						
11-Aug	1353-1539	SS, PH	abundant	50	Visual, splash; entire reach	
1994:						
16-Jun	1900-2205	PR, SS	27 adults	27	Headlamp; entire reach	*T. cyrtopsis* (dead) at rock dam.
1995:						
30-May	1249-1627	SS	1 frog	1	Visual; entire reach	2 *Ambystoma* above rock dam.
25-Jun	day	SS	abundant tads		Dipnet; rock dam to 200m down	
25-Jun	day	SS	1 frog, 2 large tads		Dipnet; vic. gaging sta.	
20-Aug	day	SS	2 ad, 3 juv		Visual; vic. rock dam	
21-Aug	1415-1645	SS	19 juv, 1 meta, 4 lg tads	24	Visual, splash; entire reach	
23-Aug	1815-1915	SS	8 frogs		Visual, at & nr rock dam	
1996:						
May	day	KC, MM	20 ad, 50 meta, many tads	70	Visual, splash; entire reach	Usual observation at site for May 1996.
1-Jul	a.m.	KC	64 frogs		Visual; rock dam to 50m down	
2-Jul	1201-1359	PR, VM	55 (mix of lg, med, sm, tads)	55	Visual, splash; entire reach	10 *Ambystoma*, 1 *T. cyrtopsis* above rock dam.

15-Jul	1400-1410	KC	2 ad, 4 meta		Visual; vic., rock dam	
21-Aug	2100-2230	PR, CS	4 lg ad, 1 med ad, 2 juv		Headlamp; at rock dam	
2-Sep	ca. 1800	PR, EW	ca. 50 ad, 1 tad	51	Visual, splash, dipnet; most of reach	6-10 ad/pool above rock dam, few below.
1997:						
7-Jul	1605-1718	VM	16 ad, 4 juv	20	Visual, splash; entire reach	
16-Jul	1517-1915	VM	6 ad, 5 juv, 10 tads	21	Visual, splash, dipnet; entire reach	Tads factorially more abund. above rock dam.
27-Aug	day	R. Llewellyn	17 ad, 13 juv, 1 meta	31	Visual from bridge to CCC dam	1316-1410 (8-27) and 0917-1314 (8-28)
14-Sep	1039-1557	PCR	25 lg ad; 6 sm ad/sub;12 juv	43	Visual, entire watered reach	1 hatched egg mass, 4 *cyrtopsis* ; 1 *bilineatus*
30-Sep	0936-1130	SF Hale	23 ad, 15 juv	38	Visual, binocs., thorough check	
1998:						
winter	mid-day	CRS	1 adult		Leading film crew	Hand-caught, prob. Lethargic
winter	NA	KC	1-2 frogs seen		General observations	Saw many fewer than in previous years
1-5-98	NA	Nina King	1 lethargic, dry-skinned frog	2	Fish survey	Frog seemed to recover at lab
15-May	1755-1911	PCR	5 ad	8	Visual, dipnet at and nr CCC rock dam	4 *Ambystoma* larvae (3-5 cm TL)/sweep in 2nd pool above dam; Dead *Gila* (* cm) in dam pool.
20-Jul	1625-1831	PCR	2 live ad (lg), 1 dead subad (1 held, rel 8-6-98)	2	Visual, dipnet	Dam pool w/ dead Rana, Spea, Chaetodipus (1 ea); Held lg ad live, healthy, skin negative fro chytrids.
5-Aug	1005-1117	PCR	2 lg adults seen	2	Visual over most of reach	Was v. dry in July; 2 big floods since; 1 *cyrtopsis* .
3-Sep	NA	MM	1 egg mass		General observations	Eggs hatching; 50 m below CCC dam
6-Sep	1536-1740	DHH, VM	8 frogs (7 ad, 1 juv)	8	Visual; 80% of reach	caught 80mm ad male; saw *cyrtopsis* pH=7.7; conduct=560; Th2o=19.5 (gaging sta.)
17-Dec	NA	Nina King	1 carcass w/ ?*Saprolegnia*?		Fish survey	lg pool bel. gaging sta.
22-Dec	NA	Nina King	1 carcass fresh (coll, frozen)		Fish survey	central reach in shallow water
1999:						
5-8-99	NA	Nina King	261 tads (sm hindlegs) moved to CCC dam pool		Fishing out drying pools	V. low water; 224 tads (65-70mm; to 99mm)-3 pools bel. CCC dam pool (w/ chubs), +37 in smaller pools.
6-Sep	1540-1714	PCR	3 ad, 7 lg juv	10	Visual of 2/3 of entire reach	Despite flash floods, water still low
14-Nov	1540-1740	E. Wallace	2 juveniles		Visual, dipnet, gaging sta. downstream	
29-Nov	NA	Nina King	frog seen		Fish work	last activity date for 1999 in regular visits
2000:						

20-Jan	1257	Nina King	3 juveniles/metamorphs		Working at CCC Dam Pool	1st activity since November
21-Jan	1000	Nina King	3 juveniles/metamorphs		Working at CCC Dam Pool	Dead one above gaging sta. (18 g ad)
23-Feb	1300	Nina King	1 adult		Working at CCC Dam Pool	
26-Feb	1300	Nina King	2 juveniles/metamorphs		Working at CCC Dam Pool	
summer	NA	MM, Nina King	max of several	5	Surveying stream for fish	Highest count seen that year
<u>2001:</u>						
spring	NA	Radke	up to 3 ad at once; 1 egg mass		General observations	At gaging sta. pool; tads also seen there .
24-Jul	1428-1612	PCR	1 ad, 1 subad, 1 juv	3	Visual of full reach	1 great blue heron landed at dam pool

Table A.2. Monitoring results for Chiricahua leopard frogs in enclosure, SBNWR, Cochise Co., Arizona, 1994-2001.

Date	Time	Observer	No. leopard frogs	Method; Annotations	
1994:			(188)	releases into enclosure, May-June)	
31-May	0843 - 0943	Rosen	18	Binoculars. all metamorphs	
15-Jun	1025 - 1035	Rosen	8	Splash count	
17-Jun	1000 - 1100	Rosen	9	Binoculars; 1 green heron	
18-Jun	0830 - 0840	Rosen	3	Splash count; 1 green heron	
6-Jul	0840 - 0910	Rosen	4	Binoculars + Splash Count; 2 green herons	
7-Jul	1203 - 1216	Rosen	2	Splash count; 1 green + 2 great blue herons	
7-Jul	2230 - 2330	Rosen	15	Headlamp. 11 juvenile, 3 metamorph, 1 tadpole	
8-Jul	0934 - 0954	Rosen	6	Splash count	
19-Jul	1847 - 1909	Rosen	12	Splash count; just after sunset	
15-Aug	1030-1100	Cobble	9	Binocs. 6 juv bullfrogs seen	
17-Aug	1030-1055	Cobble	10	Binocs. 4 juv bullfrogs seen	
18-Aug	1100-1130	Cobble	13	Binocs. 4 juv bullfrogs seen	
2-Sep	2305 - 2335	Rosen	7	Headlamp; males calling; 2 juvenile bullfrogs shot	
6-Sep	1740 - 1804	Rosen	7	Binoculars; 3 juvenile bullfrogs seen	
6-Sep	1530 - 1550	Cobble	4	Binocs; 1 checkered garter, 11 juv bullfrogs seen	
6-Sep	2103 - 2309	Rosen	7	Headlamp; garter sn removed, 13 bullfrogs shot	
9-Sep	1040 - 1055	Rosen	4	Splash count	
12-Sep	1530 - 1550	Cobble	2	Binoculars; 2 juvenile bullfrogs seen	
16-Sep	1510 - 1525	Cobble	7	Binoculars; 4 juvenile bullfrogs seen	
28-Sep	0800 - 0900	Cobble	7	Binoculars; 9 juvenile bullfrogs shot	
28-Sep	1500 - 1600	Cobble	na	Binoculars; 9 juvenile bullfrogs shot	
29-Sep	na	Cobble	na	1 checkered garter snake seen	
5-Oct	1400 - 1500	Cobble	8	Binoculars; 3 juvenile bullfrogs seen	
11-Oct	1445 - 1505	Cobble	1	Binoculars, 3 juvenile bullfrogs seen	
		mean	7.4		0.92
		95% CI	1.80		1.80
1995:					
3-Mar	a.m.	Cobble	14	Binocs. 1 adult, 13 juveniles	
10-Apr	1600-1620	Cobble	12	Binocs. 2 ad,10 juv, + 1 metamorph bullfrog	
27-May	1530-1630	Rosen	five	Dipnetting tadpoles all large	
27-May	2030-2130	Rosen	4	Headlamp. Removed one 7-8 cm bullfrog	
28-May	night	Rosen	na	Headlamp. 3 7-8 cm bullfrogs seen, 1 shot. Air cold	
31-May	night	Sartorius	na	1 bullfrog shot	
7-Jun	0630-0700	Magoffin	28	Binoculars	
8-Jun	na	Cobble	3	Binocs. 1 juvenile garter snake seen	
13-Jun	na	Magoffin	26	Binocs. All juv., + 2 bullfrogs	
15-Jun	na	Cobble	18	Binoculars. All juveniles	
21-Jun	2205-2330	Rosen	15	Headlamp. All juv. 1 lg juv. bullfrog shot	
23-Jun	0900-0920	Rosen	na	Splash count. Dipnetting yielded 1 pre-metamorph	
9-Aug	1015-1030	Cobble	8	Binocs. All juv. Dense vegetation concealing frogs	
1-Sep	2030-2130	Rosen	29	Headlamp.2 lg,many calling.1-2 metamorph bullfrogs	
2-Sep	2335-2353	Rosen	16	Headlamp. No calling. Cool. 2 sm bullfrogs	
		mean	15.7		
		95% CI	5.33		

(cont.)

1996:					
25-May	1020-1045	Rosen	31	Visual. 1 metam, 30+ tad [all in Pond 1 {NE}].	
26-May	2300-2330	Rosen	33	Headlamp. 3 metam, 30+ tads, all Pond 1.	
3-Jun	na	Cobble	26	Binocs. All metamorphs	
22-Jun	am	Magoffin	42	Binocs. All metam. 2 metam. bullfrogs.	
28-Jun	1400-1500	Cobble	70	Binocs. 2 ad, 68 juv, 2 metam. bullfrogs.	
1-Jul	na	Magoffin	100	Binocs. 2 ad, 98 juvs, 2 juv. bullfrogs.	
10-Jul	1500-1525	Cobble	43	Binocs all juv,bullfrogs:2 shot, egg mass rem.	
16-Jul	1015-1100	Cobble	68	Binocs. 2 ad, 66 juv.	
3-Aug	1115-1203	Cobble	30	Binocs. all subadult.	
12-Aug	1505-1540	Cobble	81	Binocs. most subad, 2 6" check. garter snakes.	
21-Aug	1845-1935	Rosen	27	Spalsh count. all ad/subad.	
28-Aug	1500-1515	Cobble	52	Binocs. all juv., 1 metam. bullfrog.	
31-Aug	2100-2300	Rosen	23	Headlamp [rec. calls]. All ad. 2 bullfrogs shot.	
9-Sep	1430-1500	Cobble	62	Binocs. lg and sm adults.	
30-Sep	1530-1600	Cobble	58	Binocs. All ad. 1 small leop fr egg mass [fresh].	
Oct	na	Cobble	na	1 dead frog with redleg; 1 egg mass (12 eggs taken)	
		mean	49.7		
		95% CI	11.63		
1997:					
25-Mar	na	Magoffin	6	1 frog, 5 tadpole sunning	
28-Jun	2031-2150	Miera	8	Splash count, headlamp. 1 lg bullfrog seen.	
6-Aug	2008-2128	Rosen	9	Headlamp. 2 yrling *marcianus* , 2 sm ad bullfrogs rem.	
30-Aug	1400-1430	Schwalbe	7	Binocs, with AGFD personnel also searching.	
30-Aug	2136-2231	Rosen	5	1-2 calling. W/ E.Wallace, S. Hale.	
		mean	7.0		
		95% CI	1.39		
1998:			(116)	73 DHS + 43 PCR releases to enclosure (May-June)	
20-Mar	1100-1135	Rosen	0	spalsh count, dipnetting	
20-Apr	1325-1330	Rosen	4	4 lg tads in brief walk -by	
16-May	2023-2140	Rosen et al.	7	4 spalshes, 1 meta, 2 lg tads	
23-Jun	0740-0745	Rosen	4	4 in quick walk-by	
14-Jul	2215-2330	Rosen	13	approximate census	
14-Jul		King	3		
5-Sep	2023-2140	Rosen et al.	9	careful headlamp search	
18-Sep	2030	D. Hall	6	A pair seen together (2 cm apart; calls heard)	
1-Oct		King	5	count and date approximate	
			5.67		1.25
1999:					
5-May		King	10	date and count approximate	
29-May	1000-1025	Rosen	2	quick check	
5-Sep	1328-1350	Rosen	0	intensive dipnetting (70 *R. cates* in 17 seeps)	
1-Nov		Wallace	1	date approx., 1 dead *R. chir* , dipnet, ponds almost dry	
			3.25		2.29
2000:	all year	Rosen	0	dried in fall; still moist but nothing under rocks Jan. 14	
2001:	all year	Rosen	0	dry	

Table A3. Monitoring results for Chiricahua leopard frogs in ranarium (screen room concrete pond) at SBNWR, Cochise Co., Arizona, 1996-2001.

Date	Time	Observer	No. leopard frogs	Method; Annotations
1996:				
Sept.	NA	Magoffin		Ranarium done; concrete pool earlier.
Sept.	NA	Magoffin	10	10 ad intro'd, capt'd Cocklebur Xing, GuadCynRd
Nov.	NA	Cobble		2 ad died of "redleg" following cold snap
1997:				
March	NA	Cobble		6 ad dead with "redleg", following brief cold snap
18-May	NA	Magoffin	0	6 advanced tads fr Douglas HS intro'd (orig fr Choate)
summer	NA	Magoffin	5	2 ad, 2-3 metamorphs
25-Oct	NA	Cobble		both adults found dead; chytrid confirmed
3-Nov	NA	Cobble		1 juv found dead;none left
1998:				10 metamorphs rel to ranarium, 15 June 1998 (Rosewood eggs reared at Tucson).
30-Jun	1745	D. Hall	3	3 froglets jumped into water
3-Jul	1415	Rosen	5	5 good-sized juveniles jumped in
14-Jul	1500	Rosen	3	3 3-4 cm SVL frogs jumped in
23-Jul	NA	Rosen	3	3 hefty juveniles
29-Jul	700	D. Hall	1	1 frog jumped into water; ground wet
13-Aug	2030	D. Hall	4	all about 65-80 mm SVL
5-Sep	2200	Rosen	4	4 sm adults (65-68 mm SVL), look robust.
18-Sep	2100	D. Hall	4	Saw 4, 60-75 mm SVL frogs
1999:				
31-May	1300	Rosen	0	None seen this year
18-Aug	2200	R. Lllewellyn	4	4 seen in pond
5-Sep	1100	Rosen	4	4 very large frogs seen
2000:				
14-Jan	945	Rosen	0	Ponds looks OK; sunken algae mat
15-Feb	NA	N. King	0	"no activity"
30-Mar	NA	N. King	0	"no activity"
6-Apr	NA	N. King	0	"no activity"
July	NA	N. King	0	Tadpoles found in ranarium pond
2001:				
spring	NA	Radke	4	lg ad found when pond was dried, 1 killed by desiccation; 3 lg + 60 meta + 60 lg tads transferred to North Fork stream at site of former North Pond, SBNWR. 3 lg + 60 meta + 60 lg tads transferred to North Fork stream at site of former North Pond, SBNWR. Various other tads (summing to ca. 500+) also rel. at N Fork in 2000-2001--prob none survived.

Table A.4. Monitoring results for the Chiricahua leopard frog at Rosewood Tank, Magoffin Ranch, Cochise Co., Arizona, 1993-2001.

Date	Time	Primary Observer(s)	Leopard frogs observed	Result (if any)	Survey method / extent	Other aquatic ecosystem observations
1974:						
7-Sep	afternoon	John Frost	ca. 30 *R. chir*; 2 calling, no tads	30	"kicked in"	"several" *R. cates* at "several" spring-fed SBNWR tanks
1993:						
unk	NA	SH	present		General survey	Good numbers seen (pers. comm.)
June	day	MM	ca. 200 metamorphs		General observation	Tads survived coyotes/herons that descended here
June	day	KC, MM	ca. 800 tads		Seining	From smaller remaining pool: rel. at SBNWR.
1994:						
27-Mar	2130-2230	PR, MS	4 female, 1 male, 2 tads		Headlamp (dipnetted tads).	Cold night, nr freezing.
April	day	MM	ca. 390 tads		Hand collection	Drying; split bet. newly dug RW Pool & SBNWR.
spring	NA	MM	9-18 adults	13.5	Visual, flashlight	Repeated counts under good conditions.
30-May	1716-1730	PR, SS	5 lg tads		Brief dipnetting	
30-May	2303-2319	PR, SS	10 lg ad	10	Headlamp	
10-Jun	NA	MM	16 adults	16	General observations	Ca. 10 June.
15 June	1252-1309	PR, SS	2 meta, 3 tads	5	Visual, dipnet; brief, in heat	
16-Jun	NA	MM	5 adults	5	General observations	Frogs app. dispersed after light rain.
5-Jul	1155-1211	PR	5 lg ad, 22 meta	27	Visual (binoculars)	with Brent Martin
18-Jul	night	MM	4 ad, 6 meta	10	Flashlight	removed a 3rd T. marcianus
20-Jul	1500-1519	PR, SS	6 adults	6	Splash count	
20-Jul	2304-2325	PR, SS	4 ad, 12 meta	16	Headlamp	
3-Sep	0800-0831	PR	6 ad, 1 meta	7	Visual (binocs)	1st '94 rains partly filled tank; frogs in dug pool.
3-Sep	a.m.	MM	1 ad, 7 meta	8	Visual	Mid-morning; tank was refurbished, but is leaking.
6-Sep	1305-1319	PR	4 ad, 2 juv	6	Visual	
9-Oct	p.m.	PR, MM	1 egg mass		General observations	Laid 2-3d prior; 10% failure (top layer), rest hatching.
1995:						
18-Feb	NA	MM	frogs seen		General observations	1st this yr; *R. cates* calling in Rbtsn on 21-Feb.
25-Feb	NA	MM	2 ad, 1 fresh egg mass	2	General observations	Hatching 5-Mar, w/ 8-10 bad eggs in corner of mass.

15-Apr	NA	MM	new egg mass		General observations	Second this year; date approx.
1-May	NA	MM	4-5 frogs	4.5	Visual	Date approx.
29-May	NA	PR, MM	No frogs	0	Visual (binocs.)	MM obs. 4/count recently.
23-Jul	1443-1626	SS	1 lg ad, 1 tad	2	Visual, dipnet	
August	day	MM	3 lg ad, ca. 40 tads	3	Visual	Obs. tads when adding water to dug pool.
7-Aug	NA	MM	47 tads		Intensive dipnetting	47 sm tads to Choate.
1-Sep	NA	MM	4 ad	4	Visual	
2-Sep	1420-1430	PR	No frogs	0	Visual	This happens, midday heat.
3-Sep	2005-2055	PR, MM	3 v. lg. ad; 19 tads dipnetted.	3	Headlamp; intensive dipnetting.	19 sm tads w/ hindlegs, to Choate; 1 lg *alvarius*; *T. marcianus*: lg female (rem.), 2 sm juv.
24-Sep	NA	MM	Eggs and 1" tads reported		General observations	
1996:						
spring	NA	MM	1 or 2 small frogs	1.5	General observations	In months prior to 25_May interview.
15-May	NA	MM	ca. 30 tads		Adding water	Date approx.
24-May	NA	MM	1 yg ad	1	Visual	As usual, in dug pool; tank makeover done this spg.
26-May	dusk	PR, MS, MM	2 meta	2	Visual, headlamp	From dusk to dark.
summer	NA	MM	4-5 v. lg. ad	4.5	General observations	Usual observation during July & August.
7-Aug	NA	MM	6 ad at Cockleburr Crossing		Visual; prob. all Rosewood frogs.	Guad Cyn Rd at Hay Hollow, 3.5 mi bel. Rosewood.
20-Aug	NA	MM	25 ad (Co. Cr.), 3 ad at MM HQ		Visual; prob. all Rosewood frogs.	Magoffin HQ 2 mi bel. Rosewood. Date approx.
21-Aug	1315-1420	PR, CS	No leopard frogs	0	Visual (binocs.)	1 ad, many sm juv *alvarius*.
1997:						
15-Feb	day	MM	4-5 frogs	4.5	Visual	Tank down to water in cattle footprints.
15-Mar	day	MM	5 ad (1 huge, 2 lg, 1 sm)	5	In drying pond, moved to new pool	Concrete pool finished early March. Date approx.
16-Mar	NA	MM	1 egg mass		General observations	In concrete pool, immed. after moving frogs.
28-Mar	NA	MM	2nd egg mass in concrete pool		General observations	1st egg mass pre-hatching; 2nd mass turning white.
25-May	0940-0950	PR, MM	1 adult	1	Visual	
summer	NA	MM	2 ad	2	General observations	Usual observation at concrete pool. Tank dry.
30-Aug	day	MS	1 egg mass		Visual, dipnet (no tads)	Egg mass failed; pH=10.8
1-Sep	day	MM	2 ad (1 lg female, 1 ave male)	2	Drained/refilled concrete pool	*Gambusia* (few) removed (fr. Mar. pondweed input). 2nd egg mass (submerged) also died. 5th '97 mass.
19-Sep	NA	Anna M	5 lg ad	5	General observations	In concrete pool; also 1 med *Bufo alvarius*
fall	NA	MM	5 adults	5	Dry and clean concrete pool.	Found in concrete pool.

1998:						
winter	NA	MM	None sen	0	General observations	
20-Mar	1735-1820	PCR	3 lg ad, 2 fresh egg masses	3	Visual	Coll. 5% eggs; rear in Tucson for SBNWR releases. 1 mass hatched hatched, the other 98% infertile.
24-Jun	2043-2101	PCR, DHH	4 ad, (1 huge); no tads	4	Visual, dipnet	Inverts (esp. notonectids, corixids) v. abund; 2 *Bufo alvarius* ;earthen tanks dry; all in sm concrete pond.
15-Aug	NA	MM	2 egg masses		General observations	1 fresh, 1 hatching; eggs laid in earthenpond
29-Aug	NA	HB	1 more egg mass		General observations	ribbons, hatching; eggs & frogs in concrete pool
31-Aug	NA	HB	1 more egg mass	4	General observations	fresh eggs; eggs & frogs in concrete pool
6-Sep	1200-1236	PCR, MJS	tads v. abund in concrete pool	0	Dipnetting	20-30 tads to Platz; pond w/ *debilis, multiplic, couchii*
16-Oct	1100	PCR	20 3/4 - 1 inch tads	0	Visual	Brief stop at concrete tank; '98 driest yr on record here
1999:						
April	NA	MM	No frogs; 1.5" tadpoles abund.	0	General observations	No frogs seen since October
May	NA	MM	No leopard frogs;tads abund	0	General observations	Frogs not seen yet in '99; tads are various sizes
29-May	NA	MM	1 or 2 large adults	2	Visual	daytime
30-May	morning	PCR, VM	numerous lg (85mm) tads	0	Visual	Some slow-growing tads apparently, ca. 1/3 of total
Aug	NA	CRS	1 ad, 3-4 sub/juv	4	General observations	Pond filled with one lg flood early in monsoon season
5-Sep	1800-1825	PCR	1 ad (pond); 3 lg juv (concrete)	4	Visual, binocs.	juv *Bufo alvarius* seen in pond.
late Oct	NA	MM	eggs laid in late Oct.		General observations	hatching in early November
2000:						
17-Mar	NA	MM	4-5 ad, 11 juvs; 3 egg masses	15	General observations	1 v lg old frog included
spring	NA	MM	14 yg ad (old ones not seen)	14	General observations	At concrete pool; all healthy

Table A.5. Monitoring results for the Chiricahua leopard frog at Belency Tank, Magoffin Ranch, Cochise Co., Arizona, 1994-2001.

Date	Time	Primary Observer(s)	Leopard frogs observed	Result (if any)	Survey method / extent	Other aquatic ecosystem observations
1994:						
28-Mar	midday	PR, MS, MM	3 egg masses		Inspection	1 hatching, 1 pre-hatching, 1 1/2 developed.
spring	NA	MM	17 - 25 ad	21	Visual	"Early 1994"; tank ca. 1/2 full.
30-May	1830-2030	PR, SS, MM	15-17 ad; 4 lg tads	20	Visual, headlamp, 5 seine hauls (15' net)	12-15 ad (d), 15-17(nite); *marcianus*; depth ca. 1.3m.
August	NA	MM	up to 60 frogs, various sizes		Visual	Water level still dropping; sand trap reconstructed.
7-Sep	1900-2030	PR, MM	41 ad (2.5 - ca. 4" SVL)	41	Visual, headlamp	33 main, 8 sand trap; 21 juv. *marcianus* removed
Sept.	NA	MM	NA		General	Herons feasting on anurans.
9-Oct	1200-1330	PR, MM	11 ad + 1 in net	12	Visual (binocs.); 8 seine hauls (15' net)	4 lg Yaqui chubs; 1 ad *marcianus* (rem.); depth 0.6m.
1995:						
25-Feb	NA	MM	25 frogs, 2 egg masses	25	Visual	1 fresh, 1 older egg mass
4-Mar	NA	MM	8 frogs	8	Visual	2nd egg mass disintegrating pre-hatching.
14-Apr	NA	MM	1 more eggs (for a total of 3)		Inspection	Date approx.; water level stays low w/ new well.
1-May	NA	MM	8-12 frogs	10	Visual	Date app.; several counts; Spg '95 egg masses = 6.
29-May	1630-1730	PR, MM	9 ad + 3 in net	12	Visual, ca. 6 seine hauls (15' net)	5 lg Yaqui chubs.
summer	NA	MM	NA		NA	Windmill, well installed; functioning intermittently.
August	NA	MM	ca. 12 (incl some juvs.)	12	Visual	This prior to 31-Aug flood filled sand trap.
3-Sep	2230-2310	PR, MM	15 ad (14 main, 1 sand trap)	15	Headlamp	1 ad, many meta *Bufo alvarius*.
winter	NA	MM	None seen	0	Visual	No frogs seen early winter; many herons in fall.
1996:						
winter	NA	MM	None seen	0	Visual	No frogs in late winter.
15-May	night	MM	10 frogs, several tads	15	Visual	Date approx.;1st frogs since last summer.
24-May	night	MM	5 ad	5	Visual	
26-May	2100-2150	PR, MS, MM	5 ad	5	Headlamps + flahlight	Also 1 yearling *T. marcianus*
summer	NA	MM	No frogs seen or heard	0	General	July-mid Aug, no frogs, but many toads seen/heard.
13-Aug	NA	MM	23 ad sand trap, more in pond	31.5	Visual	Frogs calling under water in main tank.
19-Aug	NA	MM	17 ad + similar no. in sand trap	28.5	Visual	Main pond partly full; all ave. or sm ad.
Nov	NA	MM	1 dead ad in drying sand trap	1	Visual	Frog had redleg.

1997:						
spring	NA	MM	None seen	0	Visual	Main tank ca. 1/2 full.
summer	NA	MM	None seen	0	Visual	Main and sand trap fill 31 July; v. few toads calling.
31-Aug	2114-2157	PR,CS, MS,MM	None seen	0	Headlamps, flashlights	1 *Bufo* (ad), 2 sm juv *S. multiplicatas*; 1 subad, 3 sm juv *marcianus* (rem.).
1998:						
winter	NA	MM	None seen	0	General observation	None seen subsequently
1999:						
11-May	NA	MM	27 tads fr DHS pond moved		RELEASE	
all year	NA	MM	No leopard frogs	0	General observations	None seen all year
2000:						
spring	NA	MM	prob. 300 tads fr DS		RELEASE	release planned for late June 2000.

Table A.6. Monitoring results for the Chiricahua leopard frog at Choate Tank and Headquarters Pond, Magoffin Ranch, Cochise Co., Arizona, 1995-2001.

Date	Time	Primary Observer(s)	Leopard frogs observed	Result (if any)	Survey method / extent	Other aquatic ecosystem observations
I. Choate Tank and Well (upper Belency drainage).						
1995:						
spring	NA	MM	NA		Tank constructed, filled	Site previously w/ windmill, storage tank, drinker.
7-Aug	NA	MM	47 med-sized tads released		RELEASE	Tadpoles from dug pool at Rosewood.
3-Sep	2130 - 2205	PR, MM	19 stunted RW tadpoles rel.		RELEASE	Tadpoles from dug pool at Rosewood.
3-Sep	2130 - 2205	PR, MM	2 meta + 1 tad	3	Visual	10mmSVL RW tads, hind legs; 2 alvarius, 1 marcianus
1996:						
15-May	NA	MM	15 dead + 10 live; date approx.	25	Visual; 2 dead examined had redleg	Pump failed, water to 0.7m deep, smelled sulphurous.
24-May	night	MM	7 sm ad	7	Visual	Frogs healthy; pump fixed ca. 16-May
26-May	2000 - 2045	PCR, MJS, MM	10 sm ad	10	Headlamps, flashlight	Frogs healthy.
summer	day	MM	10-12 frogs, ad size	11	Visual, binocs.	Several observations.
fall	NA	MM, HB	NA		3 egg masses	1/2 each egg mass (=290 tads) to Douglas h.s..
8-Dec	NA	Anna M.	1 lethargic frog		Visual	Frog inactive on Potamegeton mat, seemed sick.
1997:						
spring	day	MM	None seen	0	Visual	No frogs despite several visits.
summer	day	MM	None seen	0	Visual	No frogs despite several visits.
31-Aug	2000 - 2035	PR,CS,Ms,MM	2 sm ad on mat (healthy)	2	Headlamps, flashlights	1 lg juv *alvarius* ; 1 sm ad F *marcianus* (rem.).
19-Sep	NA	MM	2 seen about this date	2	Visual	Also one toad
1998:						
winter	NA	MM	None seen	0	Visual	
May	NA	MM	2 frogs seen	2	Visual	
Aug	NA	MM	3 frogs seen	3	Visual	
5-Sep	NA	MM	1 frog seen	1	Visual	Water level has been fluctuating, pump not good
1999:						
spring	NA	MM	No frogs	0	General observations	Well broken, pond dry

II. Magoffin Ranch Headquarters Pond.

1997:						
20-Feb	NA	MM	NA		10m diam pond completed	In Rosewood Hollow bottom, fed by house well.
24-May	NA	MM,HB	41 tads fr. DHS released		RELEASE	Tadpoles slightly stunted, w/ hind legs.
1-Aug	NA	MM	2 meta	2	Visual	2 seen on >1 occasion.
7-Aug	1900 - 1915	PR, MM	none seen	0	Headlamp, flashlight	2 neonate *marcianus* (rem.); no lg toad choruses '97.
31-Aug	2200 - 2220	PR,CS,MS,MM	none seen	0	Headlamps, flashlights	7 neonatal *marcianus*; only 4 *S. couchii* heard in '97.
1998:						
winter	NA	MM	None seen	0	General observations	
20-Mar	1830 - 1900	PCR, MM	None seen	0	Visual, binocs.	
3-Jun	NA	HB, MM	30 large tads released fr DHS		RELEASE	Egg source was SBNWR leopard frog enclosure
18-Jun	1045	DHH	21 metamorphs released		RELEASE	Rosewood eggs reared at Tucson
22-Jun	1405	DHH	22 metamorphs released		RELEASE	Rosewood eggs reared at Tucson
Aug	NA	MM	3, 5, 10 seen at once	6	Visual, binocs.	7-8 *Bufo alvarius* seen at once; 1 *marcianus* seen
1999:						
spring	NA	MM	saw frogs until mid-April		General observations	Night heron foraging here intensively since April
18-Apr	NA	MM	"couple of adults in pond"	2	General observations	One heard calling
11-May	NA	MM	12 tads fr DHS pond moved		RELEASE	MM rem. all 30 *R. cates* at Floyd in '98, then it dried.
30-May	NA	PCR, VM, MM	None seen	0	Visual search, binocs.	Cattails have gotten started here; water level constant.
mid July	NA	MM	4 ave ad, 2 lg ad	6	General observations	1 bullfrog + 5-6 ad shot last yr (Floyd Pocket dried)
Aug	NA	MM	up to 6 seen	3	General observations	Regular calling; 1 ad *R. catesbeiana* present
5-Sep	1645 - 1710	PCR, MM	no leopard frogs seen	0	Visual search, binocs.	Saw the one bullfrog; topminnows abundant
fall	NA	MM, Velasco	8-10 frogs seen regularly	9	General observations	tadpoles coll for contaminants; bullfrog gone
2000:						
spring	NA	MM	4+ adults, calling heard	4	General observations	

Table A.7. Monitoring results for the Chiricahua leopard frog at school sites in Douglas, Cochise Co., Arizona, 1996-2001.

Date	Time	Primary Observer(s)	Leopard frogs observed	Result (if any)	Survey method / extent	Other aquatic ecosystem observations
I. Douglas High School						
I.a. Small original frog pool						
1997:						
1-Feb	NA	MM,KC	None		New, small pond added, w/ fence	
27-May	NA	HB	27 lab-reared tads rel.		RELEASE	From 3 egg masses at Choate in fall 1996.
August	NA	HB	1 lg tad	1	General check	Hans & a student independantly saw tads (few).
1998:						
11-Mar	NA	HB	1 egg mass hatching		General observations	
20-Apr	0935 - 0950	PCR	18 tads (17-30 mm total length)	18	Dipnet, visual, binocs.	Lush growth of *Cladophora* and other algae.
6-Aug	1130 - 1155	PCR	2 sub (1 seen, 1 netted)	2	Dipnet, visual	Gyrinids and dragonfly nymphs abundant
1999:						
29-May	2150 - 2200	PCR, VM	2 lg ad; 6 yr-old ad	9	Headlamp search	lg olive (100-110mm); green med ad (70-85mm)
4-Sep	2030 - 2040	PCR, RL	2 ad, 5 subad	7	Headlamp search	Water looks bad; submergent vegetation gone
2000:						
14-Jan	1515 - 1520	PCR, CRS	1 v lg, 1 lg, 9 sm ad	11	Visual	Water turned off, down to a few inches
2001:						
2-Aug	1715 - 1720	PCR, C. Harris	5 spalshes	5	Visual, splash count	Ca. 1/2 adults
2-Aug	2104 - 2110	PCR, C. Harris	2 ad frogs	2	Headlamp search	visibility difficult; 1 lg ad *Bufo woodhousi*
I.b. Large original (fish) pond.						
1996:						
unk	NA	KC,MM	None	0	General observations	Old catfish, centrarchid pond.
1997:						
unk	NA	HB	None	0	General observations	no fish present late in year
1998:						
20-Apr	0950 - 1030	PCR	None	0	Dipnet, visual	*Bufo woodhousi* calling & many tads (9-12 mm)
6-Aug	1155 - 1205	PCR	None	0	Dipnet, visual	*Bufo woodhousi* tads; chubs & topminnows present
1999:						
29-May	2200 - 2250	PCR, VM	6 med ad-pond; 14 meta-bogs	20	Headlamp search	*R. cates* calling (been here all yr); 50+ *B. woodhousi*

4-Sep	2040 - 2130	PCR, RL	9 ad, 20 meta	29	Headlamp search	Hundreds present (visibility low); 3 lg *Bufo woodhousi*
2000:						
14-Jan	1520 - 1555	PCR, CRS	18 various sizes (30-70mm)	18	Visual	10-pond, 8 -new shallow pond; cat; Cooper's hawk
summer	NA	staff	NA		Hoop net	removed 2 ad *R. cates*, 2 slider turtles
all yr	NA	C. Harris	NA		Collect frogs found dead	7 specimens; none positive for chytrids
2001:						
2-Aug	1720 - 1752	PCR, C. Harris	16 splashes; 10 visual	26	Visual, binoc., splash count	19 lg pond, 7 new pond; glassed 4 ad 6 juv/meta
2-Aug	2110 - 2136	PCR, C. Harris	37 mainpond, 11 new poond	48	Headlamp search	all ad exc 1; mod. chorus; no tads; 7 lg ad *woodhousi*
II. Huber Junior High School (largest mini-pond)						
1998:						
7-Sep	1300	PCR	None; no releases yet.		Visual, dipnet	Lots of invertebrates (corixids, odonates)
1999:						
29-May	2345 - 2359	PCR, VM	3 metamorphs	3	Headlamp search	*Agosia*, shed of yrling *Thamnophis*; inverts (esp. dragonfly nymphs) v. abundant.
4-Sep	2200 - 2217	PCR, RL	6 small adults	6	Headlamp search	
2000:						
14-Jan	1600 - 1655	PCR, CRS	7 ad under rocks in moist mud	7	Visual	Pond dry (we turned water on); frogs plump
III. A Avenue School Outdoor Concrete Pond						
1998:						
7-Sep	1400	PCR	1.5 cm *R. chir* tads abundant		Visual	topminnows; 2 cm *Bufo woodhousi;* 1 feral cat
1999:						
29-May	2300 - 2320	PCR, VM	3 meta, 25 lg tads	28	Headlamp search	*Agosia*, topminnow, 1 ad 1 juv *Bufo woodhousi*
4-Sep	2135 - 2150	PCR, RL	1 sub	1	Headlamp search	
2000:						
14-Jan	1730	PCR, CRS	No frogs seen	0	Visual	
2001:						
24-Jul	0015 - 0030	PCR	2 metamorphs	2	Headlamp search	*Agosia, Poeciliopsis* present
IV. Sarah Marley School Courtyard Pond						
1998:						
7-Sep	NA	PCR			Courtyard inaccessible	"has been stocked already"

1999:						
summer	NA	Minerva Kong	"1 seen last summer"	1	General observations	School principal; app. no fish brought--mosquitos
2000:						
14-Jan	1700	PCR, CRS	No frogs seen	0	Visual	Pond looks OK (we arranged for fish)
V. Faras School Outdoor Concrete Pond						
1998:						
7-Sep	1445	PCR	None seen	0	Visual	topminnows; no frogs released here yet
Oct.	NA	VM	release 10 3" *R. blairi* tads		RELEASE	From Kvacs Lakes, Sulphur Springs Valley, AZ
1999:						
29-May	2330 - 2345	PCR, VM	None seen	0	Headlamp search	tominnows; 1 lg *Bufo woodhousi*
2000:						
14-Jan	1800	PCR, CRS	No frogs seen	0	Visual	No frogs have been reported here at any time
2001:						
24-Jul	0040 - 0055	PCR	3 lg ad (bright green)	3	Headlamp search	1 lg ad *Bufo*

APPENDIX III. GARTER SNAKE SURVEY GAZETTEER FOR 1993-2001.

The following is intended to supplement discussion in the text of the report, to serve additionally as a supplement dealing with leopard frog disease surveys, to be a repository of ecological details valuable in various ways for future surveys, and as a basis for understanding ecosystem function through observed details.

Site: Arivaca Ciénega, Pima Co., el. 3600 ft.
Habitat: Ciénega; Interior Marshland; ciénega-stream
Ownership: USFWS
Sampled: 27 June 1993 (1018-1918), 28 June 1993 (1100-1408), trapping through 30 June 1993 (ca. 1000 hr trap breakdown), P.C. Rosen, C.R. Schwalbe, S.F. Hale, B.E. Martin, P.A. Holm, S.S. Sartorius.
Methods: Set 10 standard garter snake traps (6 in pond, 2 in *Typha*-choked pool, 1 each in stream canal above and below pond), 4 baited hoop nets for turtles (in pond), 27 June 1993, (1406-1736); Considerable time spent interviewing Wayne Shifflett, Phil Guertin, Dan and Hackline Culling.

Species	Stage	Numbers
Rana catesbeiana	adult	very abundant
Rana catesbeiana	juvenile	common
Rana catesbeiana	larvae	few
Thamnophis marcianus	adult	4

Notes: High abundance of small adult bullfrogs visible in main pond. Tadpoles observed were large ones. *T. marcianus* hand captured by Steve Hale (adult female 6-27-93, 1200 hr, Not Gravid, marked 3L, SVL=664, tail=148, 116 g, good condition despite massive healed injuries. Traps caught 3 *T. marcianus*: female 3-5L, 6-29-93, Post-partem, 632mm, 161 mm, 94.7g canal stream bridge trap; female 3-6L, 6-29-93, 719mm, 49mm(stub), 217 g, same location; female 3-7L, 6-30-93, 735mm, 185mm, 210g, E side main pond).
Other Species: *Micropterus salmoides, Lepomis cyanellus, Gambusia affinis* (all abundant). 1 crayfish (species not determined) caught in snake trap in canal. *Kinosternon sonoriense* (very abundant, 62 captures in traps, various ages). Lizards recorded by PCR during indicated hours: 7 *Cnemidophorus* cf. *"sonorae"*, 2 *Cnemidophorus burti stictogrammus* (adults on gravel hillock in ciénega proper, ca. 94 and 105 mm SVL), 1 *Holbrookia maculata* (adult)

Sampled: 2 October 1993 (1300-1530), 3 October (1300-1640), 4 October (1518-1932), 5 October 1993 (1446-1722), P.C. Rosen, P.A. Holm, S.S. Sartorius.
Methods: Set 5 standard garter snake traps (3 in stream canals, 1 in Typha hole, 1 in main pond; 2 Oct. 1993, 1300-1530), add 2 fyke snake traps (in ciénega somewhere, 3 Oct. 1993, 1300-1455), check them 4 Oct. 1993, 1518-1630, final check and break them all down 5 Oct. 1993, 1446-1719. Spend other time primarily working (general search for snakes) along Arivaca Creek in perennial reaches below the ciénega, and along trails in ciénega.

Species	Stage	Numbers
Rana catesbeiana	all	abundant, as before

Notes: No snakes in traps, just a few *Gambusia* and juvenile bullfrogs. NOTE: Found 1 DOR *Thamnophis cyrtopsis* on pavement at east end of Arivaca at ciénega in 1994. Bullfrogs abundant along stream below ciénega (mostly juveniles, a few large adults).
Other Species: Ciénega vicinity: 1 *Urosaurus ornatus*. Stream below ciénega: 3 *Diadophis punctatus* (1 LOR 10-5-93, 1726hr, large adult male 457mm, 107mm 19.8 g, disgorged *flagellum* 396mm 131 mm 13 g; 2 along stream at Honnas Ranch males at 1648 hr 10-4-93, 451, 106, 18.6 g and 345, 77, 8.8 g in riparian grass), 1 *Crotalus atrox* (neonate LOA 340 mm button, at 1740 hr 10-4-93, very near the *Diadophis*), 1 *Sceloporus clarkii* (upland near stream), 1 *Urosaurus ornatus*.

Sampled: 25 July (2000hr) - 3 August (1400hr) 2000; traps open continuously; E. Wallace, D. Suhre
Methods: 1 to 5 garter snake arrays set; total trap time = 36 days, 3 hours

Species	Stage	Numbers
Thamnophis eques	Juvenile	1
Rana catesbeiana	Adult/Juvenile	abundant

Notes: neonate snake captured on 28 July 2000 in snake trap set in heavily vegetated canal near E. boundary of Refuge,
Other Species: crayfish (very abundant), mosquitofish (abundant), smallmouth bass in main pond

Sampled: 8 (1300 hr) - 9 (1830 hr) Oct. 2000; traps open continuously; E. Wallace, D. Suhre
Methods: 5 garter snake arrays set; General Search

Species	Stage	Numbers
Rana catesbeiana	Larva/Juvenile	--

Notes: *Rana catesbeiana* caught in minnow traps, General Search by E. Wallace and Suhre on 8 Oct. (1400-1535 hr) downstream of main ciénega for approx. 2 mi (juvenile. bullfrogs present (~10+)).
Other Species: None

Site: Ciénega Creek headwater basin, Road Canyon Tank, Pima County
Habitat: Earthen cattle tank (n=2)
Ownership: BLM
Sampled: 2 May 2000; 1930-2010 hr; E. Wallace, D. Suhre, J. Simms, R Donaldson
Methods: VES, hand capture

Species	Stage	Numbers
Rana catesbeiana	Adult	11

Notes: 7 *Rana catesbeiana* captured and removed
Other Species: None

Site: Empire Ranch near Ciénega Creek, Gardner Canyon crossing. El. 4480 ft.
Habitat: Intermittent-semi-perennial spring run with *Chara* and spikerush, a few *Salix* and *Populus*, mesquite, and dense big sacaton.
Ownership: BLM
Sampled: 7 May 1996 (1105-1149) and 17 June 1996 (1100-1133), P.C. Rosen, V. Miera.
Methods: General search, dipnetting.

Species	Stage	Numbers
NONE		

Notes: 200 m of 10 cm deep flow. *Polypogon* noted.
Other Species: Odonates, ephemeropterans, small black diving beetles, corixids, snails, and *Ranatra* abundant. 2 whitetail deer. 1 *Elgaria kingii* (juvenile under *Populus* bough, SVL=66, tail 117+5 regen), 20 *Cnemidophorus uniparens* (15 adult, 5 juveniles), 9 *Holbrookia maculata*, 2 *Sceloporus undulatus* (ad on ground, juveniles 1.2 m up mesquite), many more lizards heard. 17 June 1996: "more *C. uniparens* than before".

Site: Empire Gulch, Ciénega Creek
Habitat: Semi-perennial shallow ponds in large flat, big sacaton; leading down to fishless ciénega pools
Ownership: BLM
Sampled: 17 June 1996 (1835-1935), P.C. Rosen, V. Miera, and 1 April 1995 (1618-1734), P.C. Rosen
Methods: Binoculars, tromping, dipnetting.

Species	Stage	Numbers
NONE		

Notes: At the pan-ponds water quite low, and grazing pressure heavy [I found this area dry except the ciénega pools on 1 April 1995]. J. Simms described leopard frogs at headwaters pool here, with low numbers of frogs throughout below headwater pool, and section 10 the "best frog site" {in region?} in the bend above drying ponds (NE 1/4 of S10), "always small numbers of frogs". Dennis Caldwell monitored small, isolated, persistent *Rana chiricahuensis* population (1 accidental specimen to UAZ by PCR) in Empire Gulch 1999-2001.
Other Species: 1April 1995: 1 *Elgaria kingii* (ad under Populus debris near ciénega pool), 3 *Sceloporus undulatus* (juveniles, on mesquite and cottonwood debris on pan), 1 *Urosaurus ornatus* (adult), "*Agosia* uncommon in stream" {exact location of this reference not given}. 17 June 1996: no fish or frogs. 1 *Kinosternon sonoriense* (adult male, 1987-8 hatch, CL=113).

Site: Ciénega Creek at main perennial headwater, Pima Co., el. 4400 ft.
Habitat: Interior Riparian Forest, ciénega and ciénega stream
Ownership: BLM
Sampled: 7 May 1996 (1325-1629) P.C. Rosen, V. Miera
Methods: Dipnetting, stationary observation, tromping through bog, walking margins of marsh

Species	Stage	Numbers
Rana chiricahuensis	frog	1

Notes: frog flushed in dense bog near small pool; J. Simms reported small numbers of frogs and tadpoles in this environment (all the way from the headwaters down to the diversion canal near Ciénega Ranch) during intensive fish depletion sampling in previous years in this general region of ciénega stream.. My notes also record the following summary from Jeff Simms: "He sees leopard frogs every 5-10 times working a site and always in low numbers. Usually only a single tadpole is seen at a time, during a ½ day depletion [sampling for fish] sampling of a pool.
Other Species: *Gila* and *Poeciliopsis* superabundant in pools; *Dolomedes, Abedus*, dytiscids, mayfly nymphs, snails

abundant, dragonfly nymphs and *Poeciliopsis* moderately abundant in submergent mats; *Cnemidophorus uniparens* (4), *Holbrookia maculata* (2), *Sceloporus undulatus* (1), 1 redtail hawk, 1 cf burrowing owl.

Sampled: 17 June 1996 (1142-1235), P.C. Rosen, V. Miera, with M. Sredl, E. Wallace, J. Simms
Methods: Tromped and dipnetted 300 m down from source, returned via rim lands

Species	Stage	Numbers
Rana chiricahuensis	adult	1

Notes: Large adult frog seen near where fleeting 7 May observation made.
Other Species: *Kinosternon sonoriense* (1994 hatch, CL=53mm) dipnetted; *Elgaria kingii* (lg juvenile in *Cynodon/Salix* near uppermost pool), *Sceloporus clarkii* (juvenile, Populus trunk), *Urosaurus ornatus* (6 ad, 5 mud wall, 1 on *Salix*), 1 great blue heron (J. Simms reports 2 nests together ca. 5 mi downstream)

Sampled: 17 June 1996 (2100-2341), P.C. Rosen, V. Miera
Methods: Eye-shining in upper 200 m of main ciénega.

Species	Stage	Numbers
Thamnophis eques	juvenile, dead	1
Rana catesbeiana	lg ad	1
Rana chiricahuensis	lg ad	1

Notes: bullfrog in large source pool, removed to UA lab (171 mm SVL 590 g; had juvenile *T. eques* [SVL ca. 375 mm, juvenile *K. sonoriense* [CL ca. 65 mm], *Eleodes* in stomach); lg ad female *R. chiricahuensis* in 3rd pool down (SVL=87 mm).
Other Species: See notes. Also, 1 elf owl, 7 coyotes (heard on both sides), fireflies, 1 vinegaroon.

Sampled: 2 May 2000; 2130-2210 hr; E. Wallace, D. Suhre, J. Simms, R Donaldson
Methods: VES, hand capture

Species	Stage	Numbers
Rana catesbeiana	Adult	4

Notes: 1 *Rana catesbeiana* captured and removed
Other Species: None

Sampled: 22 July 2000; 1700-1920 hr; E. Wallace, AS Rogers
Methods: General search.

Species	Stage	Numbers
Thamnophis eques	Adult	1
Rana catesbeiana	Adult	2

Notes: male, SVL=605, mass=104g, healed body wound just anterior to vent, tail tip missing, severe tail squeeze=healed, bullfrogs heard vocalizing.
Other Species: Bobcat kitten, Great Blue Heron, Owl cf Barn, Hawk cf Swainson's, cattle sign

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Site: Cinco Ponds, at Cinco Canyon confluence. with Ciénega Creek confluence, Pima Co. el. 4400 ft.
Habitat: Excavated earthen cattle ponds fed by spring or ground water
Ownership: BLM

Sampled: 20 May 2000; 1705-1730 hr; E. Wallace
Methods: VES, Dipnet

Species	Stage	Numbers
NONE		

Notes: cattle presence may have spooked any snakes/frogs present
Other Species: heavily and currently grazed, all vegetation was denuded and banks are pocked with hoof prints

Sampled: 7 May 1996 (1735-1829), P.C. Rosen, V. Miera
Methods: Tromping, wading, binoculars, dipnetting.

Species	Stage	Numbers
NONE		

Notes: No apparent reason for absence of frogs: Peter Warren delivered preserved juvenile *Rana chiricahuensis* from here to UAZ, collected a few years ago. J. Simms reported a couple of hundred leopard frogs at Cinco Ponds in 1989-1990. Subsequent reports and photos from Roger Repp in 1997 showed extensive overgrazing here that might affect frogs. At Cinco Windmill (large low steel tank and muddy environs) saw just 1 *Cnemidophorus uniparens*.
Other Species: *Kinosternon sonoriense* (ad male, hatched 1990, CL=124; invertebrates fairly abundant, esp. odonates, ephemeropterans, snails, and some *Gammarus*; no fish. 1 *Crotalus atrox* ('95 yg female SVL=397, tail=27, 22 g, 2seg=complete rattle [8.2;7.2] on low ridge in mesquite)

Site: Springwater Canyon at confluence with Ciénega Creek, Pima Co., el. 4360 ft.

Habitat: Head-cut, steep-sided stream pool
Ownership: BLM
Sampled: 20 May 2000; 2000-2100 hr; E. Wallace, T. Newman
Methods: Nighttime VES (Visual Encounter Survey)

Species	Stage	Numbers
Rana catesbeiana	Adult	1

Notes: attempted to gig frog but missed
Other Species: None

Site: Ciénega Creek at Mattie Canyon confluence area ("Shangri La")
Habitat: Ciénega Creek: very rich ciénega with large stream pools, dense tule, yerba mansa beds, cottonwood-willow gallery with surrounding mesquite and big sacaton. Mattie Canyon: shallower, rockier, warmer stream with less tule, less dense vegetation, smaller and few Salix, and rockier-more gravelly substrata.
Ownership: BLM
Sampled: 17 June 1996 (1409-1607), P.C. Rosen, V. Miera, J. Simms, M. Sredl, E. Wallace.
Methods: Tromping and dipnetting for 1/3 mi in each stream.

Species	Stage	Numbers
NONE		

Notes: Site with *T. eques* in 1985-1987 (Rosen and Schwalbe, 1988), also leopard frogs until 1986, when a bullfrog was heard here (P.C. Rosen observations). Vegetation so dense that sampling is difficult. Jeff Simms reports occasionally seeing leopard frogs above the falls in previous years.
Other Species: *Agosia* superabundant, *Poeciliopsis* abundant, *Gila* moderately uncommon but abundant in large deep pools. 1 *Kinosternon sonoriense* (adult male, in Mattie Canyon, hatched 1989-1990, CL=103), 3 *Urosaurus ornatus* (adults, 2 male, 1 gravid female), 1 *Sceloporus clarkii* (ad, 4m up *Salix*), 4 *Cnemidophorus uniparens* (adult), 1 C. cf. *"sonorae"*. Jeff Simms reports coatis seen here often.

Site: Ciénega Creek at the "falls", end of BLM road EC 910 B, Cochise Co., el. 4200 ft.
Habitat: Interior Riparian Forest and Woodland, gallery forest with emergent vegetation along creek
Ownership: BLM
Sampled: 23 July 2000; 1110-1210 hr, 1300-1325 hr; E. Wallace, A.S. Rogers
Methods: VES

Species	Stage	Numbers
NONE		

Notes: nice habitat
Other Species: *Sceloporus clarkii*, *Holbrookia maculata*, Great Blue Heron

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Site: Ciénega Creek at Empire-Ciénega Ranch, Pump Canyon to Mattie Canyon reach.
Habitat: Ciénega and gallery.
Ownership: BLM
Sampled: 1 March 1995 (ca. 1700-1800), P.C. Rosen, S.S. Sartorius, S. Nelson.
Methods: General search.

Species	Stage	Numbers
Rana cf. *yavapaiensis*	adult	1

Notes: Frog jumped into brush pile in shallow scour hole in flow; species ID uncertain. Jeff Simms reported (17 June 1996): heavily grazed reach, where he has never seen any frogs.
Other Species: No data recorded.

Site: Ciénega Creek at lower end of Empire Ranch, near The Narrows.
Habitat: Ciénega-stream with open cottonwood-willow gallery and moderate density of tule et al.
Ownership: BLM
Sampled: 17 June 1996 (1645-1753), P.C. Rosen, V. Miera, J. Simms.
Methods: General search.

Species	Stage	Numbers
Rana cf. *yavapaiensis*	adult	1

Notes: Frog ID a guess. Jeff Simms reports the following for previous years' sampling ± 1.5 mi of Powerline Ford in the Narrows: many leopard frogs all the way to Pump Canyon, always at least small numbers, never none, occasional dead frogs in fall seen on pool bottoms, few turtles, 22 inch *T. eques* above ford near Fresnal Canyon.

Other Species: *Gila, Poeciliopsis, Agosia* all abundant. Pair of Cooper's hawks with a nestling, 1 *Cophosaurus texanus* (subadult on sandy bottom), 1 *Urosaurus ornatus.*

Site: Babocomari River at Babocomari Ranch, Santa Cruz Co., el. 4570 ft.
Habitat: Large ciénega; large ciénega-stream; Interior Marshland; Interior Riparian Forest; cottonwoods
Ownership: Private (Babocomari Ranch)
Sampled: 28 August 2000; 1300-1515 hr; E. Wallace
Methods: linear General Search of stream habitat and perimeter General Search of pond and ciénega

Species	Stage	Numbers
Rana catesbeiana	Juvenile/Adult	abundant

Notes: overcast and sprinkling, cool temps
Other Species: *Kinosternon sonoriense* (2)

Sampled: 3 Sept. (1930 hr) - 11 Sept. (1800 hr) 2000; traps open continuously; E. Wallace
Methods: 3 garter snake trap arrays; General Search

Species	Stage	Numbers
Rana catesbeiana	Larva/Juvenile/Adult	abundant

Notes: General Search on 9 Sept (1145-1415 hr) at main ciénega
Other Species: *Kinosternon sonoriense* (adults abundant, no hatchlings caught in snake traps), mosquitofish (abundant), smallmouth bass (abundant), crayfish (common), *Pituophis catenifer*

Sampled: 23 (1730 hr) - 24 (2030 hr) Sept. 2000; traps open continuously; E. Wallace
Methods: 2 garter snake trap arrays; General Search

Species	Stage	Numbers
Rana catesbeiana	Larva/Juvenile/Adult	moderately abundant

Notes: General Search 0n 23 Sept. (1740-1825 hr) approx. ½ mi. below dam at main pond
Other Species: None
Sampled: 24 Sept. 2000; 1600-1650 hr, 1735-1825 hr; E. Wallace
Methods: General Search along stream approx. 3 mi. below main pond

Species	Stage	Numbers
Rana catesbeiana	Adult	low

Notes: *Rana catesbeiana* not obs. until latter part of survey (i.e. further downstream
Other Species: *Kinosternon sonoriense* (4), crayfish (very abundant), mosquitofish (abundant), green sunfish (1),

Site: Babocomari River at Vaughn Canyon confluence and at Elgin, AZ, Babocomari Ranch, Santa Cruz Co., el. 4600 ft.
Habitat: Ciénega-stream, Interior Riparian Woodland
Ownership: Private, State (site near Elgin)
Sampled: 27 August 2000; 1745-1900 hr; E. Wallace
Methods: General Search

Species	Stage	Numbers
Rana catesbeiana	Adult	3

Notes: rainy weather
Other Species: crayfish (1)
Sampled: 24 Sept. 2000; 1050-1145 hr, 1210-1450 hr; E. Wallace
Methods: First survey = General Search and Dipnet of approx. 600 m of stream bed at bridge in Elgin, second survey = General Search of approx. 1 mi. of stream at Vaughn Canyon confluence, including T4 spring .

Species	Stage	Numbers
Rana catesbeiana	Larva	1
Rana catesbeiana	Adult	abundant

Notes: No obs. at Elgin site which was essentially one long pool , ~ 20 m long, constituting available aquatic habitat; lots of water in Vaughn Canyon area
Other Species: *Kinosternon sonoriense* (9), crayfish (abundant), mosquitofish, Racoon tracks, owl, red-tailed hawk

Site: Babocomari River approx. 5 mi west of the confluence with the San Pedro River, adjacent to Sanders Road, Cochise Co,
Habitat: Interior Riparian Forest; incised channel with perennial pools
Ownership: Private (Roger and Elenor Angel)

Sampled: 4 Sept. 2000; 1110-1130 hr; E. Wallace
Methods: General Search

Species	Stage	Numbers
Rana catesbeiana	Juvenile	10
Rana catesbeiana	Adult	10

Notes: mosquitofish (4), crayfish (4), *Sceloporus clarkii, Diadophis punctatus*
Other Species:

Site: Turkey Creek, S. end of Research Ranch to Canelo Ranger Station, Santa Cruz Co., el. 4900 ft.
Habitat: Rocky, ciénega stream
Ownership: USDA Forest Service, Private (The National Audubon Society, Bill Steen)
Sampled: 19 May 2000; 1215-1605 hr; E. Wallace
Methods: Linear General Search, Dipnet, from McDaniels Well to N. end of Steen's property

Species	Stage	Numbers
Thamnophis shed	Adult	1

Notes: shed found amongst rock outcroppings ~ 2 m from water
Other Species: *Kinosternon sonoriense* (35), *Urosaurus ornatus* (1), *Sceloporus clarkii* (1), *Cnemidophorus* spp.
Sampled: 26 May 2000;1810-1930 hr; E. Wallace
Methods: Linear General Search, from Canelo Ranger Station approx. ½ mi. downstream

Species	Stage	Numbers
NONE		

Notes: Mostly dry creek bed
Other Species: None
Sampled: 27 May 2000; 1200-1350 hr; E. Wallace
Methods: Linear General Search, ~ 3/4 mi. of perennial creek below Steen's property

Species	Stage	Numbers
NONE		

Notes: None
Other Species: *Kinosternon sonoriense* (1), *Urosaurus ornatus* (3), *Cnemidophorus sonorae* (3), grey hawk
Sampled: 7 June 2000; 0940-1030 hr; E. Wallace
Methods: General Search, ~ 3/4 mi. of perennial creek below Steen's property

Species	Stage	Numbers
NONE		

Notes: None
Other Species: *Kinosternon sonoriense* (12+), *Urosaurus ornatus* (1), *Cnemidophorus sonorae*
Sampled: 6 Sept. 2000;1300-1500 hr; E. Wallace
Methods: General Search

Species	Stage	Numbers
NONE		

Notes: Talked with Bill Steen who said he has seen garter snakes in his goldfish pond by his house (*T. eques* is the only species known near here so far).
Other Species: None

Site: O'Donnell Creek, from Canelo Hills Sanctuary (main ciénega) to central Research Ranch (confluence of O'Donnell and Turkey Creek canyons), Santa Cruz Co., el. 4850-4950 ft.
Habitat: Ciénega; ciénega stream; intermittent stream; Interior Riparian Forest to Woodland, cottonwood, willow, ash, walnut, to sycamore and seepwillow
Ownership: USDA Forest Service and Private (The Nature Conservancy, National Audubon Society)
Sampled: 21 May 2000; 1250-1800 hr; E. Wallace
Methods: General Search, Dipnet, approx. 800 m from lower masonry dam to just above uppermost masonry dam

Species	Stage	Numbers
Rana chiricahuensis	Larva	1
Rana chiricahuensis	Adult	2

Notes: tadpole dipnetted from small pool below middle masonry dam which also contained small green sunfish and crayfish; adults observed at pools in vic. of upper masonry dam in deergrass swale, both were large adults 80-100+ mm SVL (see June 8 annotations).
Other Species: green sunfish (common), crayfish (abundant), *Lampropeltis pryomelana* (1),*Cnemidophorus* cf. *sonorae* (1), *Urosaurus ornatus* (2), *Crotalus lepidus* (1), skunk (2),

Sampled: 24 May 2000; 1600-1915 hr; E. Wallace
Methods: Linear General Search, from upper end of ciénega to uppermost masonry dam, approx. 1400 m

Species	Stage	Numbers
NONE		

Notes: stealthy approach of garter snake and leopard frog habitat is difficult
Other Species: *Kinosternon sonoriense* (1), *Sceloporus clarkii* (1), Racoon tracks, bear scat

Sampled: 8 June 2000; 1100-1200 hr; E. Wallace
Methods: General Search, ~ 1.0 mi. of survey area from N. boundary of TNC downstream

Species	Stage	Numbers
NONE*		

Notes: * tadpole pool below middle masonry dam has dried.
Other Species: *Kinosternon sonoriense* (1)

Sampled: 14 July 2000; 2025-2225 hr; E. Wallace
Methods: nighttime General Search; call survey

Species	Stage	Numbers
Rana chiricahuensis	Adult	3

Notes: all 3 frogs were males observed vocalizing strongly in pool just below where frog was observed in May 2000, crayfish abundant in pool
Other Species: *Hyla arenicolor* (2) calling, *Kinosternon sonoriense* (1), green sunfish (2), crayfish (abundant), *Crotalus lepidus* (1)

Sampled: 10 Sept. 2000; 1110-1330 hr;; E. Wallace
Methods: General Search, Dipnet

Species	Stage	Numbers
Rana chiricahuensis	Larva	20+

Notes: tadpoles located in pool behind lowest masonry dam (=ephemeral)
Other Species: green sunfish (abundant), crayfish

Site: Finley Tank, Audubon Research Ranch, Santa Cruz Co., el. 4700 ft.
Habitat: Impounded spring, perched in pocket draw of lower O'Donnell Canyon, with dense knotgrass and spikerush and giant rush around perimeter and dense mats of submerged *Chara*, up-drainage seeps support a few cottonwoods and willows
Ownership: Private, National Audubon Society

Sampled: 18 June 1996 (1003-1108, P.C. Rosen, V. Miera.
Methods: Binocular observations, tromp-search, dipnetting.

Species	Stage	Numbers
Thamnophis eques	juvenile	1

Notes: A yearling *T. eques* foraging for fish in pond. No frogs or tadpoles. Springs still wet with open water up into the willows except above the small north tank, but flow not reaching to pond. Pond very low, >1 m below deergrass margin (normal 1980's water line), but still water depth >1 m + 0.5 m calcareous muck. *Chara* still abundant but knotgrass almost gone.
Other Species: *Cyprinodon macularius eremus* very abundant. 2 deer kills (cf. *Felis concolor*). 1 *Sceloporus clarkii* (ad, on Salix), 2 *Cnemidophorus uniparens* (ad), 7 unidentified lizards.

Sampled: 16 May (1600 hr) - 27 May (1800 hr) 2000; traps open continuously; E. Wallace
Methods: 4 garter snake trap arrays

Species	Stage	Numbers
Thamnophis eques	Juvenile	--
Thamnophis eques	Adult	16

Notes: **Other Species:** *Salvadora* sp. (1), *Masticophis bilineatus* (1), *Sceloporus clarkii*, *Holbrookia maculata*

Sampled: 6 July (1700 hr) - 7 July (1730 hr) 2000; traps open continuously; E. Wallace
Methods: 4 garter snake trap arrays, General Search

Species	Stage	Numbers
Rana catesbeiana	Adult	1
Thamnophis eques	Adult	3

Notes: On 6 July 2000 1600hr *Rana catesbeiana* captured and removed from pond, SVL = 151 mm, mass = 479 g
Other Species: None

Sampled: 13 July (2030 hr) - 16 July (2130 hr) 2000; traps open continuously; E. Wallace
Methods: 4 garter snake trap arrays, nighttime General Search

Species	Stage	Numbers
Rana catesbeiana	Adult	1

Notes: large male (SVL≅ 150 mm) narrowly escaped capture
Other Species: None
Sampled: 27 August (1230 hr) - 28 August (1745 hr) 2000; traps open continuously; E. Wallace
Methods: 4 garter snake trap arrays, General Search

Species	Stage	Numbers
Thamnophis eques	Juvenile	1
Rana catesbeiana	Adult	1

Notes: *Thamnophis eques* captured in trap on 28 Aug; attempted to remove bullfrog to no avail
Other Species: None
Sampled: 3 Sept. (1600 hr) - 11 Sept. (1635 hr) 2000; traps open continuously; E. Wallace
Methods: 4 garter snake trap arrays, 5 mesh funnel traps set in moist terrestrial sites around pond, aquatic drift-seine with 2 hoop traps (to catch bullfrog), General Search

Species	Stage	Numbers
Thamnophis eques	Juvenile	2
Thamnophis eques	Adult	3
Rana catesbeiana	Adult	1

Notes: 4 garter snakes trapped, 1 Yg-of-Yr *Thamnophis eques* visually obs.; attempt to remove *Rana catesbeiana* were unsuccessful, nothing captured in terrestrial funnel traps.
Other Species: *Kinosternon sonoriense* (1)
Sampled: 23 Sept. (1335 hr) - 25 Sept. (1100 hr) 2000; traps open continuously; E. Wallace
Methods: 4 garter snake trap arrays, 5 mesh funnel traps set in moist terrestrial sites around pond, aquatic drift-seine with 2 hoop traps (to catch bullfrog), General Search, Dipnet

Species	Stage	Numbers
Rana catesbeiana	Larva	30+

Notes: None
Other Species: None

Site: Tributary of Post Canyon including masonry dammed pond (="Post Canyon Dam"), Audubon Research Ranch, Santa Cruz Co., el. 4820 ft.
Habitat: Impounded canyon pond and rocky canyon below dam with series of bedrock tinajas
Ownership: Private (National Audubon Society)
Sampled: 25 May 2000; 1620-1730 hr, 2020-2040 hr; E. Wallace
Methods: Linear General Search, Dipnet

Species	Stage	Numbers
Rana chiricahuensis	Larva	5

Notes: tadpoles were ~110 mm TL and ~ Gosner stage 38,
Other Species: *Kinosternon sonoriense* (4), *Cnemidophorus sonorae* (1)
Sampled: 7 June 2000; 1410-1600 hr; E. Wallace
Methods: Linear General Search Dipnet

Species	Stage	Numbers
Rana chiricahuensis	Larva	9

Notes: large, late stage tadpoles in lower tinajas; pond behind masonry dam is nearly dry
Other Species: *Kinosternon sonoriense* (17), *Bufo punctatus* (1), *Cnemidophorus sonorae* (1)
Sampled: 6 July 2000; 1850 - 2145 hr; E. Wallace
Methods: General Search, Dipnet

Species	Stage	Numbers
NONE		

Notes: dipnetted for tadpoles in tinaja where previously found and obs. none, pond behind dam is at maximum
Other Species: *Hyla arenicolor* calling, *Bufo punctatus* metamorphs, Green sunfish , ~20 mm TL, lower tinaja.
Sampled: 16 July 2000; 0135-0230 hr; E. Wallace
Methods: call survey

Species	Stage	Numbers
Rana chiricahuensis	Adult	3

Notes: 2 males vocalizing and 1 female
Other Species: *Bufo punctatus* (1), green sunfish (2 small, collected from lower tinaja).
Sampled: 4 Sept. (1700 hr) - 11 Sept. (1200 hr) 2000; traps open continuously; E. Wallace
Methods: 1 garter snake trap array set for entire period; 2 fyke-net traps set 8 Sept. (1730 hr) until end of trap period; General Search; baited minnow traps and hoop traps set in tinajas below dam to sample for

exotics (6 - 10 Aug).

Species	Stage	Numbers
Rana chiricahuensis	Eggs	5
Rana chiricahuensis	Larva	moderately abundant
Rana chiricahuensis	Adult	3-5
Rana catesbeiana	Adult	1

Notes: *Rana chiricahuensis* egg masses obs. in main pond; most tadpoles or adult *Rana chiricahuensis* obs. during different types of surveys including General Search, call surveys, and trapping (i.e. 1 adult captured in minnow trap); *Rana catesbeiana* heard on several occasions
Other Species: *Kinosternon sonoriense* hatchling captured in snake traps (8), green sunfish abundant in traps below dam

Sampled: 23 Sept. (1450 hr) - 24 Sept. (2200 hr) 2000;traps open continuously; E. Wallace
Methods: 1 garter snake trap array set for entire period; General Search; 1 baited hoop trap set in tinajas below dam to sample for exotics.

Species	Stage	Numbers
Rana chiricahuensis	Larva	3
Rana sp.	Adult	1

Notes: *Rana chiricahuensis* obs. during General Search 23 Sept. (1420-1530 hr); *Kinosternon sonoriense* (21) in hoop traps, plus 3 hatchlings in snake traps.
Other Species: None

Site: Unnamed tank in small tributary of Post Canyon (marked on USDA Forest Service map in SW 1/4 of sec. 28), SSW of "Post Canyon Dam", Santa Cruz Co., el. 4900 ft.
Habitat: Earthen cattle tank (ephemeral)
Ownership: USDA Forest Service

Sampled: 24 Sept. 2000; 2230-2245 hr; E. Wallace
Methods: Nighttime General Search

Species	Stage	Numbers
Rana chiricahuensis	Adult	1

Notes: Large male, ~ 80 mm SVL
Other Species: None

Site: Unmarked tinaja in unnamed tributary of Post Canyon, ~ ½ way between Post Canyon Dam and Freeman Spring (≅0.75 mi. below Freeman Spring), Santa Cruz Co., el. 4875 ft.
Habitat: Isolated plunge pool at bedrock outcrop, gravel bottomed with submerged vegetation
Ownership: USDA Forest Service

Sampled: 25 May 2000; 1830-1900 hr, 1940 hr; E. Wallace
Methods: General Search, Dipnet

Species	Stage	Numbers
Rana chiricahuensis	Larva	2
Rana chiricahuensis	Adult	2-3

Notes: tadpoles ~ 75 mm TL and Gosner stage 35, adults obs. on return visit @ 1940 hr
Other Species: None

Sampled: 7 June 2000; 1620-1635 hr, 1750; E. Wallace
Methods: General Search

Species	Stage	Numbers
Rana chiricahuensis	Adult	3

Notes: No dipnetting, frogs obs. on return visit
Other Species: None

Sampled: 6 July 2000; 1950-2015 hr; E. Wallace
Methods: General Search

Species	Stage	Numbers
Rana chiricahuensis	Adult	3

Notes: *Rana chiricahuensis* male(s) heard vocalizing upon approach, female *Rana chiricahuensis* (SVL=100 mm) obs. in shallow plunge pool
Other Species: *Hyla arenicolor* calling

Sampled: 5 Sept. 2000; 2200-2205 hr; E. Wallace

Methods: General Search

Species	Stage	Numbers
NONE		

Notes: submergent vegetation is absent, much surface water in canyon throughout
Other Species: None

Site: Freeman Spring, in tributary of Post Canyon, Santa Cruz Co., el. 4950 ft.
Habitat: Ciénega and scour pools
Ownership: USDA Forest Service
Sampled: 25 May 2000; 1900-1920 hr; E. Wallace
Methods: General Search, Dipnet

Species	Stage	Numbers
Rana chiricahuensis	Larva	18

Notes: tadpoles ranged from ~45 - 85 mm TL and Gosner stage 25 - 38
Other Species: None

Sampled: 27 May 2000; 1535-1545 hr; E. Wallace
Methods: General Search

Species	Stage	Numbers
NONE		

Notes: checked tadpole pool for adults
Other Species: None

Sampled: 7 June 2000; 1650-1725; E. Wallace
Methods: General Search

Species	Stage	Numbers
Rana chiricahuensis	Larva	260*

Notes: *Pond has dried and all tadpoles were all dead, counted 260 from wet mud
Other Species: *Kinosternon sonoriense* (1)

Sampled: 7 July 2000; 0025-0055 hr; E. Wallace
Methods: Nighttime General Search

Species	Stage	Numbers
Rana chiricahuensis	Adult	1

Notes: male *Rana chiricahuensis* (SVL≅60 mm SVL) vocalizing strongly
Other Species: None

Sampled: 5 Sept. 2000; 2220-2235 hr; E. Wallace
Methods: General Search

Species	Stage	Numbers
Rana chiricahuensis	Eggs	1
Rana chiricahuensis	Juvenile	1

Notes:
Other Species:

Site: Unnamed tank ~ ½ mi. below Ralph tank, above Freeman Spring, Santa Cruz Co., el. 5100 ft.
Habitat: Masonry dam cattle tank, dry
Ownership: USDA Forest Service
Sampled: 27 May 2000; E. Wallace
Methods: General Search

Species	Stage	Numbers
NONE		

Notes: if tank holds water it is deep at high water mark (=6 ft),
Other Species: None

Sampled: 6 July 2000; 2340-2355 hr; E. Wallace
Methods: perimeter General Search

Species	Stage	Numbers
NONE		

Notes: tank is nearly full
Other Species: None

Site: Welch Spring in Post Canyon, Santa Cruz Co., el. 4925 ft.

Habitat: Rocky ciénega, willows
Ownership: USDA Forest Service

Sampled: 27 May 2000; 1900-1940 hr; E. Wallace
Methods: Linear General Search, Dipnet

Species	Stage	Numbers
Rana chiricahuensis	Larva	4
Rana chiricahuensis	Adult	2+

Notes: tadpoles were ~30 - 45mm TL; 1 adult was 88 mm SVL
Other Species: None

Sampled: 7 June 2000; 1905-1915 hr; E. Wallace
Methods: General Search

Species	Stage	Numbers
Rana chiricahuensis	Adult	6

Notes: None
Other Species: None

Sampled: 15-16 July 2000; 2155-0025 hr; E. Wallace
Methods: nighttime General Search

Species	Stage	Numbers
Rana chiricahuensis	Adult	3

Notes: males heard vocalizing
Other Species: *Kinosternon sonoriense* (1), *Hyla arenicolor* (2 ads, 25 tads,)

Sampled: 9 Sept. 2000; 1755-1855 hr; E. Wallace
Methods: General Search

Species	Stage	Numbers
Rana chiricahuensis	Eggs	1
Rana chiricahuensis	Juvenile	3
Rana chiricahuensis	Adult	8

Notes: males heard vocalizing at spring pool
Other Species: obvious cattle grazing

Site: Unmarked tank at windmill in Hay Canyon, ½ way between Elgin-Canelo Rd and Babocomari Ranch Rd, Santa Cruz Co.
Habitat: Small, cement-lined pond maintained by windmill with luxuriant perimeter vegetation
Ownership: Private, Babocomari Ranch

Sampled: 6 July 2000; 2300-2305 hr; E. Wallace
Methods: General Search

Species	Stage	Numbers
NONE		

Notes: None
Other Species: None

Site: Windmill tank along Elgin Rd (S. side) approx. 1.5 mi. E. of AZ 83, Santa Cruz Co.
Habitat: Ciénega-like earthen cattle tank
Ownership: Private

Sampled: 5 August 2000; 1140-1155 hr; E. Wallace, P.H. Holm
Methods: General Search

Species	Stage	Numbers
NONE		

Notes: None
Other Species: goldfish in bathtub

Site: Unnamed tank, Scotia Canyon trib. ca. 1 mi. E Parker Canyon Lake (SE1/4 sec17), Cochise Co.
Habitat: Earthen cattle tank with small ciénega habitat below berm, dense spikerush
Ownership: USDA Forest Service

Sampled: 15 July 2000; 1305-1345, 1450-1530 hr; E. Wallace
Methods: perimeter General Search and linear General Search of approximately 200 m of wash bottom below tank and 100 m of inflow drainage, Dipnet

Species	Stage	Numbers
Thamnophis sp.	Juvenile	1
Thamnophis cyrtopsis	Adult	1

Notes: Yg-of-Yr *Thamnophis* slid into main pond before positive ID.
Other Species: *Spea multiplicata*, metamorphs, *Hyla wrightorum* (5 tadpoles), *Cnemidophorus sonorae* (2), *Holbrookia maculata*

Sampled: 5 August 2000; 1340-1415 hr; E. Wallace, PH Holm
Methods: General Search

Species	Stage	Numbers
NONE		

Notes: None
Other Species: *Hyla wrightorum* (7 metamorphs, 30 tadpoles), *Sceloporus scalaris* (2), *Cnemidophorus sonorae* (1)

Sampled: 14 August (2115 hr) - 16 August (2000 hr) 2000; fykes open continuously; E. Wallace
Methods: 2 garter snake fyke traps set; General Search, Dipnet

Species	Stage	Numbers
NONE		

Notes: perimeter General Search @ ponds on 14 August (2005-2025 hr); perimeter General Search @ ponds on 15 August (1530-1550 hr)
Other Species: *Hyla wrightorum*

Site: Scotia Canyon, old site of Peterson's Ranch, Cochise Co., el. 6150 ft.
Habitat: Rocky, small permanent stream; ciénega-like tanks
Ownership: USDA Forest Service

Sampled: 15 July 2000; 1635-1653 hr, 1708-1712 hr, 1720-1750 hr; E. Wallace
Methods: Perimeter General Search of all ponds, flipped cover objects

Species	Stage	Numbers
Rana catesbeiana	Juvenile	17
Rana catesbeiana	Adult	12

Notes: None
Other Species: unidentified fish (=*Ambystoma tigrinum*?) at upper main pond

Sampled: 5 August (1630 hr) - 6 August (1630 hr) 2000; traps open continuously; E. Wallace, P.H. Holm
Methods: 5 garter snake trap arrays, General Search

Species	Stage	Numbers
Thamnophis eques	Juvenile	1
Thamnophis eques	Adult	1
Rana catesbeiana	Adult/Juvenile	abundant

Notes: Snakes captured in uppermost main pond at old house site; 1030-1330 hr survey Scotia Cyn proper
Other Species: *Sceloporus scalaris* (1), *Sceloporus jarrovii* (1), *Pituophis catenifer* (1), *Elgaria kingii* (1)

Sampled: 11 August (1750 hr) - 16 August (1930 hr) 2000; E. Wallace
Methods: 7 garter snake trap arrays, General Search

Species	Stage	Numbers
Thamnophis eques	Adult	1
Rana catesbeiana	Larva/Juvenile/Adult	abundant

Notes: *Thamnophis eques* captured in trap on 12 August 2000 @ main pond; General Search of canyon on 13 August (1300 -1420 hr); General Search of canyon and pond perimeters on 15 August (1205-1405 hr);
Other Species: *Ambystoma tigrinum* (1)

Site: Bog Hole Wildlife Management Area, head of San Rafael Valley, Santa Cruz Co., el. 5050 ft.
Habitat: Impounded pond (= Interior Marshland), isolated cottonwoods
Ownership: AGFD

Sampled: 7 July 2000; 1140-1340 hr; E. Wallace
Methods: Perimeter General Search

Species	Stage	Numbers
Rana catesbeiana	Larva	100's-1000's
Rana catesbeiana	Juvenile	1000's
Rana catesbeiana	Adult	15+

Notes: rain storm moving in
Other Species: Coyote skull, racoon tracks, possible obs. of fish although could have been tadpoles

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Site: Santa Cruz River, from vic. of Sheehy Spring to the International Border, Santa Cruz Co., el. 4700 ft.
Habitat: Interior Riparian Woodland dominated by cottonwood, well-vegetated (knotgrass, smartweed, deergrass, some submergent and floating vegetation), incised river channel, occasionally braided with ample backwaters.
Ownership: Arizona State Parks, Private (R. Humphreys)
Sampled: 14 July 2000; 1325-1415 hr, 1530-1640 hr; E. Wallace
Methods: General Search, Dipnet, early survey consisted of ~ 1/4 mi. of river above the International Boundary and later survey was upstream from here towards State Park north boundary, near FS 61 bridge, total ≅ 1.25 miles.

Species	Stage	Numbers
Thamnophis sp.	Juvenile	1
Rana catesbeiana	Larva	abundant
Rana catesbeiana	Juvenile	6
Rana catesbeiana	Adult	15

Notes: Garter snake obs. along bottom of pool near International Boundary
Other Species: Centrarchids (green sunfish, smallmouth bass) and mosquitofish are abundant, longfin dace (abundant), Grey Hawk, Harrier, Great Blue Heron, racoon tracks
Sampled: 12 August (2030 hr) -13 August (2030 hr) 2000; trap open for 24 hours, E. Wallace
Methods: General Search, Dipnet, 1 garter snake array set ~ ½ mi. below bridge

Species	Stage	Numbers
Thamnophis sp.	Juvenile	1
Thamnophis eques	Juvenile	1
Thamnophis eques	Adult	1
Rana catesbeiana	Eggs	1
Rana catesbeiana	Larva/Juvenile/Adult	abundant

Notes: General Search on 13 August (2045-2125 hr) approx. 500m of river below FS 61 bridge; General Search on 14 August (1110-1440 hr) approx. 1.5 mi. of river above International Boundary (*Thamnophis* sp.); General Search on 16 August (1100-1315 hr) approx. 1 mi. of river above bridge (*Thamnophis eques* adult female); General Search on 16 August (1515-1630 hr) approx. 1/4 mi. above International Border (*Thamnophis eques* Yg-of-Yr); 1 garter snake array set ~ ½ mi. below bridge on 12 -13 August for 24 hrs;
Other Species: *Kinosternon sonoriense*, *Bufo woodhousii*, Centrarchids (green sunfish, smallmouth bass) and mosquitofish are abundant, longfin dace (abundant)

Site: Upper 13 Reservoir, base of Patagonia Mountains, Santa Cruz Co., el. 5000 ft.
Habitat: Small, shallow earthen cattle tank, some submergent vegetation
Ownership: USDA Forest Service
Sampled: 12 August 2000; 1810-1820 hr; E. Wallace
Methods:

Species	Stage	Numbers
NONE		

Notes: None
Other Species: None

Site: Heron Spring, San Rafael State Park, Santa Cruz Co.
Habitat: Ciénega, pools in incised arroyo
Ownership: Arizona State Parks
Sampled: 14 August (1920 hr) - 16 August (1715 hr) 2000; trap open continuously; E. Wallace
Methods: 1 snake fyke trap set in ciénega; General Search

Species	Stage	Numbers
Rana catesbeiana	Juvenile	5

Notes: General Search on 14 August (1725-1735 hr) approx. 100 m of all aquatic habitat
Other Species: Poecilliids

Site: Sheehy Spring, San Rafael Valley, Santa Cruz Co., el. 4700 ft.
Habitat: Ciénega, pools in incised arroyo, bermed cattle tank at mouth in river bottom
Ownership: Private (R. Humphreys)
Sampled: 15 August 2000; 1800-2015hr, 1330-1350 hr; E. Wallace
Methods: General Search

Species	Stage	Numbers
Thamnophis eques	Juvenile	1
Rana catesbeiana	Juvenile/Adult	abundant

Notes: Yg-of-Yr *Thamnophis eques* found underneath board in valley bottom near bermed tank
Other Species: *Spea multiplicata* (tads abundant), Poeciliids (abundant), *Elgaria kingii* (1)
Sampled: 16 August 2000; 0945-1100 hr; E. Wallace
Methods: General Search

Species	Stage	Numbers
NONE		

Notes: None
Other Species: None

Site: Sharp Spring, San Rafael State Park, Santa Cruz Co., el. 4700 ft.
Habitat: Ciénega, Interior Riparian Forest, willow, cottonwoods
Ownership: Arizona State Parks
Sampled: 14 August (1920 hr) - 16 August (1715 hr) 2000; E. Wallace
Methods: 1 garter snake array, General Search

Species	Stage	Numbers
Rana catesbeiana	Larva/Juvenile/Adult	abundant

Notes: General Search on 14 August (1555-1640 hr) approx. 1/3 mi. of aquatic habitat
Other Species: *Kinosternon sonoriense*, Poeciliids (abundant)

Site: Barchas Ranch, Wild Duck Pond, Brown Cyn watershed, E side Huachuca Mts, Cochise Co.
Habitat: Ciénega-like earthen cattle tank
Ownership: USDA Forest Service
Sampled: 16 July 2000; 1330-1350 hr; E. Wallace
Methods: Perimeter General Search, Dipnet

Species	Stage	Numbers
NONE		

Notes: None
Other Species: None

Site: Barchas Ranch House Pond, Brown Cyn watershed, E side Huachuca Mts, Cochise Co.
Habitat: Ciénega-like, earthen cattle tank, currently has been dried
Ownership: USDA Forest Service
Sampled: 16 July 2000; 1405-1410; E. Wallace
Methods: General Search

Species	Stage	Numbers
NONE		

Notes: None
Other Species: *Cnemidophorus sonorae* (1)

Site: Garden Canyon Boy Scout Cabin Pond, Fort Huachuca, Cochise Co.
Habitat: Small ciénega, dense spikerush
Ownership: Department of Defense
Sampled: 16 July 2000; 1530-1550 hr; E. Wallace
Methods: General Search of pond and 200m below in stream, Dipnet

Species	Stage	Numbers
NONE		

Notes: None
Other Species: crayfish present

Site: Caponera Tanks, 2 tanks in upper Los Encinos Canyon, Baboquivari Mountains, Pima Co. el. 4160 ft.

Habitat: Impounded cattle tanks in rocky canyon
Ownership: State Trust Land

Sampled: 6 Nov. 1999; 1730-1815 hr; E. Wallace
Methods: General Search

Species	Stage	Numbers
Rana chiricahuensis	Adult	1

Notes: 1 plop heard at lower tank
Other Species: None

Sampled: 6 Nov. 1999; 1840-2010 hr; E. Wallace
Methods: Nighttime General Search;

Species	Stage	Numbers
Rana chiricahuensis	Adult	2

Notes: 1 male heard calling at lower tank, 1 male captured at upper tank w/ stretched vocal sacs, SVL=102 mm
Other Species: None

Sampled: 23 June 2000; 1850-1915 hr; E. Wallace
Methods: Perimeter General Search, Dipnet

Species	Stage	Numbers
Rana chiricahuensis	Adult	4

Notes: *Rana chiricahuensis* were approx. 65-85 mm SVL; weather wasn't the best for surveying, storm moving in
Other Species: *Bufo alvarius* (4), *Ambystoma tigrinum* (7+) all dead

Sampled: 29 July 2000; 2035-2125 hr; E. Wallace
Methods: Perimeter General Search

Species	Stage	Numbers
Rana chiricahuensis	Juvenile	40+
Rana chiricahuensis	Adult	16

Notes: None
Other Species: *Ambystoma tigrinum* (8), 2 dead

Sampled: 12 Nov. 2000; 1530-1620 hr; E. Wallace
Methods: General Search

Species	Stage	Numbers
Rana chiricahuensis	Larva	100+

Notes: None
Other Species: None

Site: Antonio Tank, Baboquivari Mountains, Pima Co., el. 4240 ft.
Habitat: Earthen cattle tank
Ownership: State

Sampled: 29 July 2000; 2220-2230 hr; E. Wallace
Methods: Perimeter General Search (X2)

Species	Stage	Numbers
Rana chiricahuensis	Adult	1

Notes: 1 large female (90-100 mm SVL) obs. on second pass of tank
Other Species: *Bufo alvarius* (14)

Site: Saguaro Tank, Baboquivari Mountains, Pima Co., el. 4080 ft.
Habitat: Earthen cattle tank, mostly un-vegetated
Ownership: State

Sampled: 29 July 2000; 1730-1835 hr; E. Wallace
Methods: General Search, Dipnet

Species	Stage	Numbers
Rana chiricahuensis	Adult	100+

Notes: frogs were all ~ 60 mm SVL
Other Species: *Thamnophis cyrtopsis* (neonate), *Bufo alvarius* tadpoles

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Site: Garcia Tank, BANWR, San Luis Mountains, Pima Co.
Habitat: Earthen cattle tank
Ownership: BANWR

Sampled: 7 Nov. 1999; 0915-0935 hr; E. Wallace, D. Suhre
Methods: General Search, Dipnet

Species	Stage	Numbers
Rana chiricahuensis	Larva	2

Notes: tadpoles dipnetted from shallows in submerged vegetation
Other Species: racoon and canid tracks
Sampled: 30 June 2000; 1430-1500 hr; E. Wallace, D. Suhre
Methods: General Search

Species	Stage	Numbers
Rana chiricahuensis	Juvenile	25-35

Notes: dipnetted 10-12 times, no tadpoles
Other Species: *Bufo* tads abundant, *Cnemidophorus burti* (1)
Sampled: 18 Sept. 2000; 1100-1110 hr; E. Wallace
Methods: General Search

Species	Stage	Numbers
NONE		

Notes: Tank is dry.
Other Species: None
Sampled: 12 Nov. 2000; 1845-1910 hr; E. Wallace
Methods: Nighttime General Search

Species	Stage	Numbers
NONE		

Notes: very methodical survey, visibility good, no tadpoles obs.
Other Species: None

Site: Chivo Rock Tank, BANWR, Pima Co.
Habitat: Earthen cattle tank and series of pools below berm , rocky substrate
Ownership: USFWS
Sampled: 18 Sept. 2000; 1355-1505 hr; E. Wallace
Methods: Perimeter and linear General Search of pond and drainage below

Species	Stage	Numbers
Rana chiricahuensis	Juvenile/Adult (???)	4

Notes: plop count, age class unknown
Other Species: None

Site: Unmarked tank in tributary of Yank Canyon, S. of Yank Tank, SE of Ruby, AZ., Santa Cruz Co.
Habitat: Cattle tank
Ownership: USDA Forest Service
Sampled: 30 Jan. 2000; 1114-1120 hr; E. Wallace, J.A. Fenstermacher
Methods: Perimeter General Search

Species	Stage	Numbers
NONE		

Notes: None
Other Species: None

Site: Sycamore Canyon at confluence of Yank's Canyon,
Habitat: Interior Riparian Woodland
Ownership: USDA Forest Service
Sampled: 30 Jan. 2000; 1430-1545 hr; E. Wallace, J.A. Fenstermacher
Methods: General Search, downstream ca. 1.5 mi.

Species	Stage	Numbers
Rana chiricahuensis	Adult	2
Rana chiricahuensis	Larva	30+

Notes: *Rana chiricahuensis* adults found dead and collected
Other Species: American Dipper

Site: Black Tank and down canyon to confluence with Sycamore Canyon, SE of Ruby AZ., Santa Cruz Co.
Habitat: Cattle tank and rocky canyon in oak woodland

Ownership: USDA Forest Service
Sampled: 30 Jan. 2000; 1220-1425 hr; E. Wallace, J.A. Fenstermacher
Methods: Perimeter General Search of tank and Dipnet, General Search of aquatic habitat in canyon

Species	Stage	Numbers
Rana chiricahuensis	Adult	1

Notes: *Rana chiricahuensis* observed in plunge pool near Sycamore Cyn. confluence
Other Species: Cattle use moderate to heavy

Site: Casita Spring, tributary of upper Sycamore Canyon, SE of Ruby, AZ
Habitat: Small spring system in incised arroyo, ≤ 50 m of surface water
Ownership: USDA Forest Service
Sampled: 12 March 2000; 0950-1045; E. Wallace, A. Lipsky
Methods: General Search, much Dipnet

Species	Stage	Numbers
NONE		

Notes: small area was sampled intensively, lots of invertebrates
Other Species: some cattle sign observed inside enclosure

Site: Summit Reservoir at jct. FS rd 39 & 39A, Atascosa Mountains, Santa Cruz Co.
Habitat: Earthen cattle tank, moderate to heavy cattle use
Ownership: USDA Forest Service

Sampled: 13 March 2000; 1125-1135; E. Wallace, A. Lipsky
Methods: General Search

Species	Stage	Numbers
Rana sp.	Adult	1

Notes: ranid plop, no positive id, no *Rana catesbeiana* alarm call heard
Other Species: *Kinosternon sonoriense* (4),

Site: Crescent Spring at Alisos Well in Sycamore Canyon, Patagonia Mountains, Santa Cruz Co.
Habitat: Spring is dry but dammed mine adit cutting into rock holds water
Ownership: USDA Forest Service
Sampled: 17 June 2000; 1440-1500 hr; E. Wallace
Methods: General Search, climbed back in adit with flashlight

Species	Stage	Numbers
NONE		

Notes: not ranid frog habitat
Other Species: *Hyla arenicolor* (6), *Bufo alvarius* (1), all in adit

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Site: Aqua Caliente Canyon, from ~2800 - 3000 ft elevation, Santa Catalina Mountains, Pima Co.
Habitat: Sonoran Riparian Deciduous Woodland, rocky rugged canyon with interspersed ash trees
Ownership: Private and USDA Forest Service
Sampled: 9 Feb. 2000; 1700-1810; E. Wallace
Methods: linear General Search

Species	Stage	Numbers
NONE		

Notes: None
Other Species: *Hyla arenicolor* (1), green sunfish (abundant, most 20-30 mm TL), racoon tracks

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Site: Pontatoc Canyon (Alamo Canyon No. 1), Santa Catalina Mountains, Pima Co. AZ
Habitat: Small desert canyon, very little perennial water
Ownership: USDA Forest Service
Sampled: 24 Feb. 2000
Methods: linear General Search

Species	Stage	Numbers
NONE		

Notes: None
Other Species: None
Sampled: 15 April 2000; 1800-1815 hr; E. Wallace

Methods: General Search of 2 tinajas at lower end of canyon near USDA Forest Service boundary

Species	Stage	Numbers
NONE		

Notes: None
Other Species: None

Site: Finger Rock Canyon
Habitat: Small desert canyon, very little perennial water
Ownership: USDA Forest Service
Sampled: 15 April 2000; E. Wallace
Methods: linear General Search

Species	Stage	Numbers
NONE		

Notes: None
Other Species: None

Site: Tanque Verde Canyon below the falls, Rincon Mountains, Pima Co.
Habitat: Sonoran Riparian Deciduous Woodland, rocky rugged canyon with interspersed ash trees
Ownership: USDA Forest Service
Sampled: 16 April 2000; E. Wallace
Methods: linear General Search

Species	Stage	Numbers
NONE		

Notes: None
Other Species: *Hyla arenicolor* (2, one dead and fuzzy), mosquitofish or mollies (abundant)

Site: Unnamed Canyon and tank (major tributary south of Tanque Verde Canyon), Rincon Mountains, Pima Co.
Habitat: Rocky, rugged canyon with interspersed ash trees and earthen cattle tank
Ownership: USDA Forest Service
Sampled: 16 April 2000; 1840-1900 hr; E. Wallace
Methods: linear and perimeter General Search, Dipnet

Species	Stage	Numbers
Rana yavapaiensis	Eggs	1
Rana yavapaiensis	Larva	20
Rana yavapaiensis	Adult	12

Notes: All frogs obs. were in tank, 2 males vocalizing, tadpoles observed in bedrock tinaja in canyon bottom just above falls (none obs. in tank)
Other Species: Something large surfacing, fish or tiger salamander?

Site: Montrose Canyon, from USDA Forest Service boundary upstream ~ 0.5 mi., Santa Catalina Mountains, Pima Co.
Habitat: Interior Riparian Woodland, interspersed ash
Ownership: USDA Forest Service
Sampled: 20 Feb. 2000; 1400-1650 hr, E. Wallace, J. Rourke
Methods: linear General Search

Species	Stage	Numbers
Rana yavapaiensis	Adult	3
Rana yavapaiensis	Larva	30+

Notes: All metamorphosed individuals were dead.
Other Species: *Hyla arenicolor* (1)
Sampled: 5 April 2000; 1210-1800 hr; E. Wallace D.H. Hall
Methods: General Search, Dipnet

Species	Stage	Numbers
Rana yavapaiensis	Larva	52+

Notes: most tadpoles were ~40-60 mm TL and Gosner stage 28
Other Species: *Thamnophis cyrtopsis* (1) with large bolus, *Hyla arenicolor* juveniles (2)

Site: Romero Canyon from canyon mouth at mountain base to FS Trail 8 crossing, Santa Catalina

Mountains, Pima Co.
Habitat: Sonoran/Interior Riparian Woodland
Ownership: USDA Forest Service
Sampled: 24 March 2000; 1230-1800 hr, E. Wallace, D.H. Hall
Methods: linear General Search, minimal Dipnet

Species	Stage	Numbers
NONE		

Notes: None
Other Species: 1 Thamnophis cyrtopsis , 1Kinosternon sonoriense, green sunfish (abundant), black bullhead (1)

Site: Unnamed Canyon WSW of Duquesne by ~ 1.5 mi. (sec. 4), Patagonia Mountains, Santa Cruz Co.
Habitat: Mostly dry canyon except for a vertical mine adit with good water
Ownership: USDA Forest Service
Sampled: 17 June 2000; 1620-1800 hr; E. Wallace
Methods: General Search

Species	Stage	Numbers
NONE		

Notes: Overcast and cool, no lizard activity
Other Species: None

Site: San Pedro River at Highway 90
Habitat: Big Cottonwood and mesquite gallery forest, good-sized stream.
Ownership: BLM
Sampled: 30 June 1996 (1121-1405), P.C. Rosen, V. Miera, P. Langdale.
Methods: Dipnetting, seining, general search of terrestrial habitat.

Species	Stage	Numbers
Rana catesbeiana	adult	uncommon
Rana catesbeiana	juvenile	mod. common
Rana catesbeiana	larvae	common

Notes: High water from record early rains yesterday and last night, already receding below the inner high banks to 0.5 - 1.3 m deep, workable with the available nets. Most larval bullfrogs and fish were caught in a single large muddy-bottomed backwater pool. Larval bullfrogs were 12-15 cm LOA with hindlegs or 1.5-2 cm.
Other Species: *Gambusia affinis* (common), *Lepomis cyanellus* (common), *Ameiurus melas* (moderately common), *Micropterus salmoides* (moderately common), 1 *Catostomus insignis* (small adult). *Orconectes virilis* (very abundant). 1 green heron. *Cnemidophorus uniparens* (all ages, superabundant in leaf litter of outer gallery margins).
Sampled: 5 April 1998 (1400-1505), P.C. Rosen, D.H. Hall, M. Muro.
Methods: Seining, dipnetting, searching along banks and in gallery.

Species	Stage	Numbers
Rana catesbeiana	larvae	35

Notes: Larvae moderately abundant to uncommon, in main channel in quiet runs and in large gravelly, shallow backwater: all large (4 inches, except 1 at 2 inches). River level moderately high. Some pools here are huge, 1-2 m deep,. > 10 m across and 100 m long. Heritage Database has 1996 record for *T. eques* for this region (with photo, not examined by authors).
Other Species: Deep runs: 9 *Orconectes virilis* (moderately abundant), 27 bullfrogs tadpoles (moderately abundant). Large pools: (1 *Lepomis cyanellus* (large adult), 1 *Micropterus salmoides* (subadult), 4 *Gambusia affinis*. Large backwater: 8 bullfrog tadpoles (abundant), 251 *Agosia chrysogaster* (250 fry, 1 adult), 3 *Gambusia affinis*, 1 *Lepomis cyanellus* (juvenile), 2 *Orconectes virilis*). Riffle-run: 151 *Agosia chrysogaster*.
Sampled: 16 July 2000; 1745-1845 hr; E. Wallace
Methods: linear General Search for approx. 1 mi.

Species	Stage	Numbers
Rana catesbeiana	Juvenile	30+

Notes: Interior Riparian Forest, cottonwood-willow; deeply incised channel with little bank vegetation
Other Species: crayfish moderately abundant

Site: Lewis Springs adjoining San Pedro River, north of Highway 90.
Habitat: Sizable ciénega-steam with open willow gallery and relatively sparse tules, well developed pools of moderate depth, with good stands of *Chara, Cladophora, Rorippa*, and water chestnut (?).
Ownership: BLM
Sampled: 5 April 1998 (1126-1311), P.C. Rosen, D.H. Hall, M. Muro.
Methods: Stomping, dipnetting, turning cover.

Species	Stage	Numbers
Rana catesbeiana	juvenile	3

Notes: Mild sunny day not optimal for snake activity. Water 15 degC.
Other Species: *Agosia chrysogaster* (moderately abundant + 3 schools of fry), *Lepomis cyanellus* (several in the largest, deepest pool, 20 m east of the old RR station fence, collected a large adult), *Orconectes virilis* (very abundant; including many small 5 mm long ones in the submergent vegetation. Dolomedes (abundant), damselfly larvae (abundant), 1 yellow-spotted dytiscid, 1 water strider, 1 syrphid (?) Larva), no snails: aquatic vegetation and invertebrates better than usual with crayfish, perhaps an early-spring phenomenon. 2 *Kinosternon sonoriense* (subadult female 1990 hatch CL ca. 90mm; very old large male, CL ca. 140 mm). 1 *Sceloporus clarkii* (large male under board), 1 *Cnemidophorus uniparens* (subadult, active under a board). 2 buteos (gray or black).

Site: San Pedro River bottoms at Curtiss Flat, Acequia Pond.
Habitat: Earthen canal and adjoining *Typha*-choked marsh-pond in disturbed area.
Ownership: Unknown
Sampled: 29 June 1996 (1635-1745), P.C. Rosen, V. Miera, P. Langdale.
Methods:

Species	Stage	Numbers
Rana catesbeiana	adult	many, calling
Rana catesbeiana	metamorphs	veery abundant
Rana catesbeiana	larvae	50

Notes: All larvae were in pond, none in canal, although metamorphs were all over.
Other Species: *Gambusia affinis* (ubiquitous, uncommon), *Orconectes virilis* (common in canal).

Site: San Pedro River at Cascabel, 34 mi (by Pomerine Rd) north of I-10.
Habitat: Productive desert stream (97% overgrown with *Nitella*[?], *Lemna, Rorippa*, filamentous algae, and *Typha*) with open cottonwood gallery forest, with *Salix* and mesquite-saltcedar thickets.
Ownership: Unknown
Sampled: 29 June 1996 (1341-1450), P.C. Rosen, V. Miera, P. Langdale.
Methods: General search ½ km, dipnetting, minnow seine.

Species	Stage	Numbers
Rana yavapaiensis	larvae	4
Rana catesbeiana	adult	1

Notes: Tadpoles: 3 large with medium-well developed hind legs, 1 small (3.5 cm LOA without hind legs), hard too catch in the dense algae, but in all habitat types. The large female bullfrog was at the best pool (2 by 3 feet and about 12-18 inches deep) among the 3 pools found in this reach, and retreated into a brush pile on the bank. Much recruitment of willows
Other Species: *Agosia chrysogaster* (superabundant), *Gambusia affinis* (moderately common in small eddy-pools, *Belostoma* superabundant. 2 *Cnemidophorus* cf. *sonorae*, 1 *Cnemidophorus uniparens*, 1 unidentified adult *Cnemidophorus*, 1 *Cophosaurus texanus* (adult), 1 *Sceloporus clarkii* (juvenile, lg willow, base). Pair of zone-tailed hawks.

Site: San Pedro River @ San Manuel crossing, Pinal Co.
Habitat: Warm temperate interior strand, heavy silt layer in river
Ownership: Private
Sampled: 12 Dec. 1999; 1630-1715 hr; E. Wallace
Methods: 100m of General Search, Dipnet

Species	Stage	Numbers
Rana yavapaiensis	Larva	30

Notes: Most tadpoles dipnetted from submergent vegetation, most ~ 30mm TL
Other Species: Racoon and canid tracks

Site: San Pedro River at Dudleyville crossing
Habitat: Warm temperate interior strand
Ownership: The Nature Conservancy
Sampled: 24 March 2000; 2145-2340 hr; E. Wallace
Methods: Nighttime General Search, ca. 400m of both banks

Species	Stage	Numbers
Rana yavapaiensis	Adult	7

Rana yavapaiensis	Larva	100's
Rana yavapaiensis	Eggs	5

Notes: heard weak vocalizations twice, most egg masses were hatching(ed)
Other Species: *Bufo woodhousei* (15+ adults, 1 egg mass), *Trachemys scripta* (1), crayfish (1), unidentified fish
Sampled: 25 March 2000; 1230-1430 hr; E. Wallace
Methods: General Search, both banks ca. 400 m, Dipnet

Species	Stage	Numbers
Rana yavapaiensis	Adult	1

Notes: *Rana yavapaiensis* female = 80 mm SVL
Other Species: Channel catfish (1), many small longfin dace, racoon and canid tracks

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Site: Bingham Ciénega
Habitat: Impounded ciénega, button-bush marsh
Ownership: Private, The Nature Conservancy
Sampled: 13 Dec. 1999; 1600-1620 hr; E. Wallace
Methods: 50 m of General Search

Species	Stage	Numbers
NONE		

Notes: None
Other Species: None
Sampled: 23 Jan. 2000; 1100-1200 hr; E. Wallace, J.E. Fonseca
Methods: General Search along west bank and through button-bush marsh to spring source

Species	Stage	Numbers
Rana catesbeiana		1
Rana spp.?		1

Notes: Fonseca heard a frog give *Rana catesbeiana* release call (squeak) and saw another *Rana* into water
Other Species: No cattle

Site: San Pedro River adjacent to Bingham Ciénega, Pinal Co.
Habitat: Beaver dam impounded stream, dense mats of algae and watercress
Ownership: Pima Co.
Sampled: 23 Jan. 2000; 1215-1245 hr; E. Wallace; J.E. Fonseca
Methods: General Search along west bank only

Species	Stage	Numbers
Rana yavapaiensis	Larva	12+
Rana sp.	Adult	3

Notes: Observations of *Rana* sp? consisted were of auditory, no positive ID
Other Species: Beaver, unidentified fish

Site: Unmarked Tank in Tucson Wash, W. of Mammoth, AZ, Pinal Co. el. 2600 ft.
Habitat: Cattle tank, mostly un-vegetated
Ownership: State Trust Land
Sampled: 23 Jan. 2000; 1450-1510 hr; E. Wallace, J.E. Fonseca, J.D. Windes
Methods: Perimeter General Search

Species	Stage	Numbers
Rana sp.	Adult	1

Notes: Heard plop only, Windes obs. many *Rana yavapaiensis* and largemouth bass here in 1998
Other Species: Heavy cattle use and recreational use

Site: Unmarked spring in Tar Wash, NW of Mammoth, AZ, Pinal Co. el. 2800 ft.
Habitat: Site consists of 3 rock/mortar catchments impounding seepage from bedrock outcrops, grazed
Ownership: State Trust Land
Sampled: 23 Jan. 2000; 1625-1635 hr; E. Wallace, J.E. Fonseca, J.D. Windes
Methods: General Search of all available water, Dipnet

Species	Stage	Numbers
Rana yavapaiensis	Adult	~10

Rana yavapaiensis	Larva	≥6

Notes: None
Other Species: None

Site: Buehman Canyon, Santa Catalina Mts., from FS rd. 801 to Diablo Canyon confluence, Pima Co.
Habitat: Sonoran Interior Riparian woodland
Ownership: Private
Sampled: 7 April 2000; 1100-1700 hr; E. Wallace, J.A. Burdett
Methods: General Search

Species	Stage	Numbers
Rana yavapaiensis	Adult	5
Rana yavapaiensis	Larva	100's

Notes: adult frogs measured 45-65 mm
Other Species: *Hyla arenicolor* (20+ ads, 20+ tads), *Kinosternon sonoriense*, zone-tailed hawk (pair), red-tailed hawk

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Site: Paige Creek, Rincon Mountains, from Paige Well to ~ 0.75 mi. below FS 35 crossing (=Clopton Ranch), Pima Co.
Habitat: Interior Riparian Woodland
Ownership: USDA Forest Service and Private
Sampled: 25 Feb. 2000; 1320-1715 hr; E. Wallace, A.S. Rogers
Methods: General Search, limited Dipnet

Species	Stage	Numbers
Rana yavapaiensis	Adult	5
Rana yavapaiensis	Larva	30+

Notes: **3 of 5 adults were dead and other 2 appeared sluggish in activities, tadpoles were from recently hatched egg mass.
Other Species: None

Site: Buckhorn Spring in Buckhorn Canyon, Rincon Mountains, Pima Co.
Habitat: small, rocky ciénega
Ownership: USDA Forest Service
Sampled: 25 Feb. 2000; 1745-1815; E. Wallace, A.S. Rogers
Methods: General Search

Species	Stage	Numbers
Rana yavapaiensis	Larva	100+

Notes:
Other Species: ringtail cat scat

Site: Bass Canyon from confluence with Hot Springs Canyon upstream to FS 691, Galiuro Mountains, Cochise Co.
Habitat: Interior Riparian Woodland
Ownership: State Trust Land and Private (TNC)

Sampled: 22 Nov. 1999; 1400-1700 hrs; E. Wallace
Methods: General Search, Dipnet

Species	Stage	Numbers
Rana yavapaiensis	Larva	2
Rana yavapaiensis	Adult	4

Notes: ** One frog was dead, longfin dace (1), speckled dace (1), chub, sucker
Other Species: None

Site: Halfmoon Tank and Stronghold Canyon, Dragoon Mountains, Cochise Co.
Habitat: Earthen cattle tank and intermittent canyon
Ownership: USDA Forest Service

Sampled: Jan. 2000; 1530-1630 hr; E. Wallace
Methods: Perimeter and linear General Search,

Species	Stage	Numbers

NONE

Notes: thin layer of ice covering part of pond
Other Species: None

Site: Irrigation pond S. and adjacent to Dragoon Rd, ~ 1.0 mi. from jct. With AZ 191
Habitat: Irrigation sump; muddy, silty earthen pond
Ownership: Private
Sampled: 15 Nov. 1999; 1305-1315 hr; E. Wallace
Methods: General Search, Dipnet

Species	Stage	Numbers
None		

Notes: known *Rana blairi* site
Other Species: *Ambystoma tigrinum* larvae dipnetted

Site: Horsefall Canyon from Pinery Canyon to Iron Spring, Chiricahua Mountains, Cochise Co.
Habitat: Series of small pools and cement stock drinker, box elder, sycamores; Interior Riparian Woodland to Forest
Ownership: USDA Forest Service
Sampled: 13 Feb. 2000; 1330-1500 hrs; E. Wallace
Methods: linear General Search

Species	Stage	Numbers
NONE		

Notes: ice present on some pools
Other Species: scrub jay, chipmunk, gopher sign, bear scat

Site: Monkey Tank in Pinery Canyon, Chiricahua Mountains, Cochise Co.
Habitat: Earthen cattle tank (~10 X 5 X 0.2 m), barren, no vegetation
Ownership: USDA Forest Service
Sampled: 13 Feb. 2000; 1600-1615 hr; E. Wallace
Methods: perimeter General Search, Dipnet (n=13)

Species	Stage	Numbers
NONE		

Notes: None
Other Species: dead skunk

Site: Pine Canyon @ Methodist Camp, Chiricahua Mountains, Cochise Co.
Habitat: Interior Riparian Deciduous Forest
Ownership: USDA Forest Service
Sampled: 13 Feb. 2000; 1720-1755 hr; E. Wallace
Methods: linear General Search, 200-300 m

Species	Stage	Numbers
NONE		

Notes: None
Other Species: whiskered screech owl

Site: SBNWR leopard frog enclosure, Cochise Co.
Habitat: Dugout earthen tanks
Ownership: USFWS
Sampled: 4 Nov. 1999; 2200-2340 hr; E. Wallace
Methods: nighttime General Search

Species	Stage	Numbers
Rana catesbeiana	Larva	1000+

Notes: tadpoles found dead/dying in (dried) ponds 1 and 4, ponds 2 and 3 still contained standing water and no *Rana catesbeiana* observed
Other Species: racoon tracks
Sampled: 5 Nov. 1999; 0940-1200 hr; E. Wallace
Methods: General Search, Dipnet

Species	Stage	Numbers
Rana catesbeiana	Larva	460

Rana catesbeiana	Juvenile	6
Rana chiricahuensis	Adult	1

Notes: *Rana chiricahuensis* adult was found dead on the bottom of pool (SVL=76.5 mm); tadpoles dipnetted and found dead in drying mud, pond #3 = 420 tadpoles in 15 dipnets (55-95 mm TL and Gosner stage 25-37); metamorphs were observed in/around ponds and under rocks in drying pools
Other Species: *Thamnophis marcianus* (1) captured eating *Rana catesbeiana* metamorph (=64 mm SVL), unmarked, SVL=248 mm, tail=64mm; racoon tracks

Sampled: 13 Nov. 1999; 1600-1620 hr; E. Wallace
Methods: General Search, Dipnet

Species	Stage	Numbers
Rana catesbeiana	Larva	~100

Notes: all tadpoles were dipnetted
Other Species: None

Site: SBNWR, North Fork, Cochise Co.
Habitat: Artificial stream system
Ownership: USFWS

Sampled: 13 Nov. 1999
Methods: nighttime General Search, surveyed from bottom end "upstream"

Species	Stage	Numbers
Rana catesbeiana	Adult	8
Rana catesbeiana	Juvenile	8

Notes: adult frogs ranged between ~100-120+ mm SVL,
Other Species: none

Sampled: 14 Nov. 1999; 1100-1200 hr; E. Wallace, N. King
Methods: Seined pool # 2, minnow trap

Species	Stage	Numbers
Rana catesbeiana	Larva	1

Notes: No tadpoles in seine hauls, incidentally trapped tadpole in trap-end used to block pool outflow, TL=127, Gosner stage ~35
Other Species: None

Sampled: 14 Nov. 1999; 2100-2145 hr; E. Wallace
Methods: nighttime General Search, gigging

Species	Stage	Numbers
Rana catesbeiana	Juvenile	13
Rana catesbeiana	Adult	7

Notes: attempted removal of *Rana catesbeiana* with gig was relatively unsuccessful, gigged 1 and hand captured 2
Other Species: None

Sampled: 15 Nov. 1999; 0845 hr; E. Wallace
Methods: 4 minnow traps set previous day ~1200 hr

Species	Stage	Numbers
Rana catesbeiana	Larva	2

Notes: both tadpoles captured in pool #2
Other Species: None

Site: SBNWR ranarium
Habitat: Enclosed small concrete pond
Ownership: USFWS

Sampled: 5 Nov. 1999; 1245-1250 hr
Methods: Quick General Search

Species	Stage	Numbers
NONE		

Notes: None
Other Species: N/A

Sampled: 22 April 2000; 0100-0105 hr; E. Wallace
Methods: General Search

Species	Stage	Numbers
Rana chiricahuensis	Adult	2

Notes: 1 dead *Rana chiricahuensis* in screened pump mechanism

Other Species: N/A

Site: Leslie Canyon, SBNWR, Cochise Co.
Habitat: Interior Riparian Forest, ciénega stream to intermittent stream below dam
Ownership: USFWS
Sampled: 14 Nov. 1999; 1540-1740 hr.; E. Wallace
Methods: General Search, Dipnet; from gauging station to just over halfway downstream towards bridge

Species	Stage	Numbers
Rana chiricahuensis	Juvenile	1
Rana sp.	Juvenile	1

Notes: *Rana chiricahuensis* dip-netted dead off bottom of pool, collected on ice, no decaying odor but skin discolored and starting to sluff around thigh, muscles seemed mushy (i.e possibly *Lethocerus* mortality as there were many of them present)
Other Species: None

Site: SBNWR headquarters greenhouse pond
Habitat: Small plastic lined pool in greenhouse
Ownership: USFWS
Sampled: 15 Nov. 1999; 1110 - 1130 hr; E. Wallace
Methods: General Search, tactile search of bottom of pool

Species	Stage	Numbers
Rana chiricahuensis	unknown	2-3

Notes: only heard plops upon approach to pond
Other Species: N/A

APPENDIX IV. TABLES SUMMARIZING SNAKE OBSERVATIONS AT SBNWR.

Appendix IVA. Annual breakdown of snakes observed at and near San Bernardino/Leslie Canyon NWR, Cochise Co., Arizona.

SPECIES	1985	1986	1987	1988	1989	1992	1993	1994	1995	1996	1997	1998	1999	Total
Arizona elegans	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Lampropeltis getula	2	2	1	4	1	1	3	2	9	3	5	9	2	44
Masticophis bilineatus	0	1	0	0	0	0	0	1	3	7	3	1	2	18
Masticophis flagellum	3	3	5	2	5	2	11	10	20	11	5	14	8	99
Pituophis melanoleucus	1	1	2	6	0	2	8	2	15	9	6	9	7	68
Rhinocheilus lecontei	0	0	0	1	0	1	3	1	3	1	4	0	1	15
Salvadora grahamiae	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Salvadora hexalepis	0	0	0	0	0	2	0	3	5	4	1	3	0	18
Senticolis triaspis	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Tantilla hobartsmithi	0	1	1	0	0	0	0	0	0	3	2	0	0	7
Trimorphodon biscutatus	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Diadophis punctatus	0	0	0	0	0	1	1	1	0	0	2	0	0	5
Heterodon nasicus	0	0	0	0	0	0	0	0	0	2	0	0	0	2
Hypsiglena torquata	0	0	1	0	0	2	0	1	2	0	3	0	0	9
Thamnophis cyrtopsis	0	0	0	0	0	0	0	4	1	4	8	2	0	19
Thamnophis eques	2	8	9	12	12	10	20	14	31	9	16	4	1	148
Thamnophis marcianus	3	5	7	6	21	10	64	69	222	160	151	157	132	1007
Thamnophis sp.	0	4	1	0	2	1	7	2	5	1	2	3	2	30
Micruroides euryxanthus	0	0	1	0	0	0	0	0	0	0	1	0	0	2
Crotalus atrox	6	2	2	5	2	3	11	9	14	9	18	15	12	108
Crotalus molossus	0	0	0	0	0	0	1	0	5	2	4	2	1	15
Crotalus scutulatus	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Crotalus tigris	0	0	0	0	0	0	0	2	0	0	0	0	0	2
unknown, escaped	0	0	0	0	0	0	1	0	0	1	1	2	1	6
Year Total	17	27	30	36	43	35	134	122	335	226	232	221	169	1627

Appendix IVB. Locality breakdown of snakes observed at and near San Bernardino / Leslie Canyon NWR, Cochise County Arizona, 1985-1999.

SPECIES	Leslie Canyon	Guadalupe Canyon	Geronimo Trail	Malpai Ranches	Astin Spring	Upper Black Draw	Central Black Draw	Lower Black Draw	North Pond	Mesquite Pond	Oasis Pond	Twin Pond	Evil Twin	Bathhouse Well	Double PhD	Robertson Cienega	Leopard Frog Enclosure	Tule Pond	SBNWR Upland Mesas	SBNWR Roads	House Pond	total
Arizona elegans	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Lampropeltis getula	0	0	0	0	1	1	4	2	11	1	1	4	5	1	4	2	3	0	1	3	0	44
Masticophis bilineatus	13	1	3	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	18
Masticophis flagellum	0	1	7	1	2	3	4	8	24	4	3	21	0	4	0	5	1	0	3	8	0	99
Pituophis melanoleucus	3	5	11	1	0	3	3	0	10	2	2	11	0	1	1	1	1	0	3	10	0	68
Rhinocheilus lecontei	0	0	2	1	0	0	0	0	2	0	0	1	1	0	1	2	0	0	3	1	1	15
Salvadora grahamiae	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Salvadora hexalepis	1	1	1	1	0	3	0	0	1	0	0	4	1	0	0	1	0	0	1	3	0	18
Senticolis triaspis	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Tantilla hobartsmithi	0	0	0	0	0	0	0	0	1	1	0	0	0	1	1	0	0	0	3	0	0	7
Trimorphodon biscutatus	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Diadophis punctatus	2	0	0	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	0	0	0	5
Heterodon nasicus	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Hypsiglena torquata	1	0	0	0	0	1	1	0	3	0	0	1	1	0	0	0	0	0	1	0	0	9
Thamnophis cyrtopsis	16	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19
Thamnophis eques	0	0	0	0	0	0	18	11	38	2	0	50	15	0	0	14	0	0	0	0	0	148
Thamnophis marcianus	0	0	1	41	5	3	3	11	144	35	28	252	229	13	115	93	8	2	0	4	20	1007
Thamnophis sp.	0	0	0	0	0	0	0	3	4	3	2	10	4	1	2	1	0	0	0	0	0	30
Micruroides euryxanthus	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Crotalus atrox	11	0	21	5	1	2	1	4	20	5	1	13	1	0	3	2	0	0	4	12	2	108
Crotalus molossus	13	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
Crotalus scutulatus	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
Crotalus tigris	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
unknown, escaped	0	0	0	0	0	0	0	0	1	0	0	1	0	1	2	0	0	0	1	0	0	6
total	64	15	49	51	9	16	34	39	263	53	37	368	257	22	130	121	13	2	20	41	23	1627